4.0 DETAILED ANALYSIS OF ALTERNATIVES

This section provides a detailed analysis of individual alternatives against each of nine evaluation criteria and a comparative analysis that focuses upon the relative performance of each alternative against those criteria. The first two criteria are threshold criteria that must be met by each alternative. The next five criteria are the primary balancing criteria upon which the analysis is based. The final two criteria are referred to as modifying criteria and evaluate state and community acceptance. The two modifying criteria will be evaluated following comments received during the public comment period and will be addressed in making the final remedy decision and discussed in the ROD.

The two **threshold criteria** are:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

The five **balancing criteria** upon which the detailed analysis is based are:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

The two **modifying criteria** are:

- State Acceptance and Tribal Consultation and Coordination
- Community Acceptance

4.1 EVALUATION PROCESS AND CRITERIA

This section provides a brief description of the nine evaluation criteria and the evaluation process used in the detailed analysis.

4.1.1 Spatial Scales

The analysis includes an evaluation using relevant exposure scales for receptors covered by each RAO. The evaluation of benthic risk was conducted on a point-by-point scale based on the empirical and predicted toxicity since these receptors are generally not mobile. Site-wide and smaller spatial scales were used to understand the effects of the alternatives in reaching the RAOs. To conduct the smaller spatial scale evaluation, the site was first subdivided into nearshore areas, the navigation channel, and Swan Island Lagoon resulting in the following four river segments:

- West shore to west navigation channel boundary
- Navigation channel
- East navigation channel boundary to the east shore
- Swan Island Lagoon

This subdivision is preferred given the differing sediment dynamics and hydrodynamics of the shorelines and lagoon, current and future uses (such as navigation channel), and the preference of many receptors for shoreline habitat. Subdivisions will allow for a more precise analysis of risk reduction for each alternative.

Since the exposure area of a mobile receptor, such as a fish or bird, is uncertain, several spatial scales were evaluated: 1) 0.2 RM was used for RAO 5 because spatial scales of ecological receptors ranged from a point to 1 RM, 2) 0.5 RM was used for RAO 1 (sediment only) for direct contact exposure of people engaged in fishing activities, and 3) 1 RM was used for RAOs 2 and 6 for the dietary exposure of humans and ecological receptors that consume fish and shellfish.

Contaminant concentrations are depicted using a “rolling” average, which is a SWAC of rolling 0.2, 0.5, or 1-mile increments of the East Shore, West Shore, or Navigation channel. The rolling averages were developed using the surface sediment data from the FS database. Those data were initially assigned to the nearest tenth of a river mile based on their location. Within each tenth of a river mile, a SWAC was calculated for the west side, navigation channel, east side, and Swan Island Lagoon. Those SWACS were then used to derive the 0.2-, 0.5-, or 1-river mile SWACs.

Thirteen individual regions of the river within the Site were designated as sediment decision units (SDUs). SDUs were generally identified as areas where focused COC rolling 1 RM averages concentrations were the highest (**Figures 4.1-1a** through **4.1-1ac**). This corresponds to the approximately estimated 1 mile exposure area over which recreational fishing and the home range of species such as smallmouth bass, hooded merganser, osprey, bald eagle and mink. Additional SDUs were defined to address areas where multiple contaminants and/or benthic risk were identified at elevated concentrations between RM 4 and 6. Locations of the SDUs and their predominant contaminants are shown on **Figure 4.1-2**. A summary of information for each SDU, including location in the river, length, acres, basis for establishing the SDU and key focused COCs within each SDU is provided in **Table 4.1-1**. The effectiveness of each remedial alternative is evaluated in part by comparing the alternative’s post construction SWAC and the PRGs for each RAO in the SDUs.

4.1.2 Modeling Remedial Alternatives

The LWG used a hydrodynamic and sediment transport (HST) model and presented the results in the Draft FS (LWG 2012). EPA commissioned external expert reviews of this model (Jay 2012, Hayter ??), which identified several shortcomings that limit its usefulness in predicting sediment transport within Portland Harbor. Some of the main concerns are:

- The HST model used models for channel flow (EFDC) and channel sediment transport (SEDZLJ). However, these modules were not coupled, such that changes in bed elevation due to deposition and erosion predicted by the SEDZLJ module are not coupled back into the EFDC module in each time step.

- The calibration of the HST model is limited.

    - The calibration of the model rests entirely on attempts to reproduce observed difference between the 2003 and 2009 bathymetry, a time period without a major flood. There was no calibration of the model to predict sediment concentrations accurately.

    - The HST model did not demonstrate that it was capable of correctly simulating tidal flows in the lower Willamette.

- The HST model does not accurately account for the complex circulation patterns of Multnomah Channel.

- While the physical CSM emphasizes the importance of bedload transport indicating that about half the sediment load into the site occurs from bedload transport, the HST model does not include this transport process.

EPA also compared the results of the HST model to the 2003-2009 bathymetry data. A statistical analysis using simple regression was conducted to determine the predictability of the HST model. The methodology is presented in Appendix F and results are presented on **Figure 4.1-3**. Each graph on this figure represent an SDU and each dot is an HST grid cell. The results indicate that there is no correlation between the HST model predictions and the bathymetric change between 2003 and 2009 and that the model bias is always positive (more deposition is predicted than was actually measured). EPA attempted to conduct an MNR analysis using the Sed CAM model, but encountered many of same issues identified in the evaluation of the accuracy and predictability of the HST model.

EPA has concluded that the HST model predictions are inconsistent with the CSM for this site, as it shows significant concentration reductions occurring within the first 10 years. However, given that the majority of the contamination was released into the river 30-80 years ago and similar reductions have not been observed, the model results appear inconsistent with the empirical data collected during the RI.

For the reasons stated above, EPA believes there is too much uncertainty in the current version of the HST model predictions to quantify the predicted reductions in sediment concentrations due to natural processes such as sediment deposition.

4.1.3 Evidence for Natural Recovery

Natural recovery processes (Magar et al 2009) including chemical transformation, reduction in contaminant mobility and bioavailability, physical isolation (or burial), and dispersion are occurring to varying degrees throughout the Willamette River. Also, since the alternatives address varying volumes of the most contaminated sediment in the river, eliminating these source areas will promote and accelerate the natural recovery processes.

Burial is a primary mechanism for natural recovery. Over time, cleaner sediment deposits on top of more contaminated sediment, decreasing contaminant exposure. Deposition is well documented in areas of the Willamette. A clear example of the depositional nature of the river is the harbor area where routine navigation dredging is needed and conducted. Since the 40-foot channel improvement project in the 1960s, navigation maintenance dredging on the Willamette River federal navigation channel is typically required on a 3 to 5 year cycle, with amounts of dredged material varying between cycles and locations on the river. The total volume of maintenance dredging in the navigation channel between 1973 and 1995 was approximately 4.4 million cy equating to an average of about 200,000 cy per year. Location specific determinations of deposition can also be obtained from analyzing bathymetric surveys. A series of high resolution bathymetric surveys were conducted within the Portland Harbor Study Area at five different times between 2002 and 2009 (Jan 2002, July/September 2002, May 2003, February 2004, and January 2009). These can be used to estimate the depth of sediment deposition over the timeframes for the areas encompassed by the surveys.

One of the limitations associated with using bathymetric survey pairs to estimate sediment deposition is that the surveys are a “snapshot” in time and may not represent the dynamic nature of the sediment bed over time. As an example, **Figure 4.1-4** shows the bathymetric change in an SMA between RM 5 and 6. The survey pairs range from generally erosional, to stable, to depositional between sequential survey pairs. This figure illustrates the dynamic nature of the sediment bed and the uncertainty associated with the conclusion that elevation changes between two surveys progressed evenly over time. This type of sediment bed behavior may also influence natural recovery: the process of burial would be interrupted during erosive periods, but dispersion would increase, if contaminated sediment was eroded.

Figure 4.1-5a-h evaluates the consistency of erosion or deposition processes between the different bathymetric surveys (the 5 different surveys have 10 different potential pairs for a bathymetric change analysis). Four types of results were generated 1) consistently erosional: all 10 pairs were either neutral or >2.5 cm/year; 2) consistently depositional: all pairs were either neutral or <-2.5 cm/year; 3) consistently neutral: all pairs were between -2.5 and +2.5 cm/yr; and 4) dynamic equilibrium, where there were a mix of results. This figures indicates that many areas of the site are in dynamic equilibrium, where both erosion and deposition occur. For many areas of the site, the determination of deposition, and the assertion that burial is a viable long-term recovery mechanism, is highly dependent on which survey pair is selected.

Another challenge with using bathymetric surveys to indicate deposition rates is the incomplete coverage in shallow areas because it is difficult for survey boats to maneuver and obtain quality data. It is also the case that many of the areas of interest are also shallow. Not surprisingly, the entirety of the 6-Nav SDU is included, but, for example, 55% of 5.5W is included. The lack of information in these areas of interest lessens the ability to determine whether natural recovery is occurring.

Fish tissue concentrations that have been sampled over time to evaluate whether they can indicate natural recovery processes. An exact comparison between sample years is not possible because sampling and compositing schemes vary between years, but comparison of the 2012 data to the 2007 data (most similar in sampling protocol) are suggestive of declines in PCB concentrations in the system (see **Figure 4.1-6**) at some locations in the harbor. These declines likely resulted from natural recovery as well as source control efforts. The 2012 fish tissue data will serve as an excellent baseline for future evaluations of decreases in fish tissue PCB concentrations; however, baseline data for other bioaccumulative contaminants will need to be established in remedial design.

In summary, natural recovery processes are occurring in the system and are anticipated to continue, particularly after in-water contaminant source areas have been addressed (i.e. contaminated sediment alternatives and upland source control). While the desire for explicit predictions of long-term outcomes is recognized, the ability to predict outcomes are currently unreliable. Consequently, the evaluation of protection and risk reduction due to natural processes will be made on the concentration reductions and residual risk at the completion of construction (i.e., at MNR Year 0). It should be recognized that the remedial alternatives will not meet all of the remedial goals for protection of human health immediately following construction and predicting declines in sediment concentrations and associated risks will only be evaluated in a qualitative comparative manner.

4.1.4 Overall Protection of Human Health and the Environment

This criterion draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. It describes how risks associated with each exposure pathway would be eliminated, reduced, or controlled through treatment, engineering or institutional controls.

Human Health

The protection of human health is assessed by comparing the PRGs for RAOs 1 (sediment only) and 2 to estimated contaminant concentrations in sediment at the completion of construction. To determine whether the tissue PRGs for RAO 2 are expected to be achieved, predicted concentrations in sediment at MNR Year 0 are used to estimate concentrations in fish and shellfish tissue. Where the estimated tissue concentrations exceed PRGs for RAO 2, then it will be assumed that a fish consumption advisory will be necessary to provide protection in the short- and/or long-term.

A qualitative assessment of protectiveness for RAOs 1 (beaches), 3 and 4 will be conducted, as there are no current means to quantitatively assess the effectiveness of the remedial activities on overall concentrations in beaches, surface water, and pore water. The assessment will be conducted at the same time frames as for RAOs 1 and 2.

Environment

The protection of the environment is assessed by comparing the PRGs for RAOs 5 and 6 to the estimated concentrations at the completion of construction.

A qualitative assessment of protectiveness for RAOs 7, 8, and 9 will be conducted in this FS, as there are no current means to quantitatively assess the effectiveness of remedial activities on overall concentrations in surface water. The assessment will be conducted at the same time frames as for RAOs 5 and 6.

4.1.5 Compliance with ARARs

Alternatives are assessed as to whether they meet applicable or relevant and appropriate federal and state requirements (ARARs) (see Section 2.1) unless such ARARs are waived under CERCLA Section 121(d)(4). Compliance with ARARs is determined by whether an alternative will meet all of the chemical-specific, action-specific, and location-specific ARARs and/or those that are to be considered (TBC) identified in **Tables 2.1-1** through **2.1-3**.

4.1.6 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time, once clean-up levels are met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of engineering (remedial technologies) and institutional controls to manage those risks. The evaluation of long-term effectiveness and permanence evaluation starts at the time RAOs and PRGs are met.

4.1.6.1 Magnitude of Residual Risks

The magnitude of residual risks for each alternative includes both human health and ecological risks. While some residual risk figures are presented in this section, all the residual risk figures are provided in Appendix H.

Human Health

The process of evaluating estimated future risks uses the methodology and assumptions, presented in the baseline risk assessment. For purposes of comparing relative reductions in risks, carcinogenic risks and non-carcinogenic health hazards are estimated for the most protective RME scenarios only. Arsenic, mercury, BEHP, PDBEs, and pentachlorophenol are not included in the evaluation of future risks via consumption of fish because no relationship has been established between concentrations in sediment and predicted concentrations in fish tissue. Exposure point concentrations (EPCs) for post-remedial exposures are based on modeled estimates of contaminant concentrations in sediment, representing the range of predicted concentrations at the completion of construction.

Ecological

The assessment of residual ecological risks relies on the predicted sediment concentrations at the completion of construction. Ecological hazard quotients are calculated using the estimated sediment concentrations and the risk-based PRGs for RAOs 5 and 6, consistent with the process used in the BERA. Residual risks are only calculated for the most sensitive receptor. Additionally, benthic risk is evaluated by determining the percentage of measured or predicted benthic toxicity points addressed by the construction of the alternative.

4.1.6.2 Adequacy and Reliability of Engineering and Institutional Controls

This factor assesses the adequacy and suitability of engineering and institutional controls that are used to manage untreated wastes or treatment residuals remaining at the site. Containment systems (caps and CDF) and institutional controls will be assessed to determine that contaminant exposures, including residuals, to human and ecological receptors are within acceptable levels.

Repairs, maintenance, and other activities conducted in perpetuity will be necessary for various caps and the on-site CDF, if constructed. Monitoring, including measurement of COC concentrations in sediment, water column, pore water, groundwater and biota is another long-term component of the remedial alternatives. Monitoring of caps will be conducted to ensure and document the integrity and effectiveness of the cap in isolating contaminants. Cap repairs are assumed to be conducted as needed throughout O&M during a hundred year period.

Upland source control measures designed to prevent the migration of contamination to the river will also need to be evaluated long-term; however, this FS assumes that all upland sources are adequately controlled and will not evaluate their effectiveness.

Upland source control measures designed to prevent the migration of contamination to the river will also need be to be evaluated for necessary repairs and maintenance performed under 5-year reviews of the CERCLA action.

4.1.7 Reduction of Toxicity, Mobility, and Volume through Treatment

CERCLA expresses a preference for remedial alternatives employing treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances. This evaluation will primarily focus on PTW, but will also include reduction in mobility of other contaminants by confinement under a reactive cap.

4.1.8 Short-Term Effectiveness

Short-term effectiveness addresses the time needed to implement the remedy and any adverse impacts that may be posed to the community, workers, and the environment during construction and operation of the remedy until cleanup levels and RAOs are achieved.

The evaluation of short-term effectiveness includes the risks to workers and the community from transport of wastes and borrow materials, risks to workers on dredges or barges, measures to address those risks, numerical estimates to demonstrate that residuals can be successfully managed during dredging or capping activities, and BMPs to mitigate environmental impacts, such as emissions or noise.

Relevant experience at other sites is used to support implementation timeframes for in-water technology assignment components. Additionally, quantitative dredge production calculations are performed based on Schroeder and Gustavson (2013). Capping implementation timeframes are based on a review of similar types of capping projects and not specifically calculated for this project.

Time to achieve RAOs and PRGs will be quantitatively evaluated at the completion of construction and qualitatively evaluated post construction (see discussion in Section 4.1.2 regarding limitations in the ability to evaluate this quantitatively). This evaluation will be conducted at varying spatial scales relevant to the RAOs and within SDUs. While some rolling river mile figures are presented in this section, all the rolling river mile figures are provided in Appendix I.

4.1.9 Implementability

The technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation is evaluated under this criterion. Metrics used to gauge the relative magnitude of technical and administrative implementability of the alternatives include the surface areas actively managed for all active technologies and volumes. Areas and volumes managed are considered proportional to the degree of implementation difficulty. Acreage subject to MNR is also considered because it requires significant administrative effort over the long term to oversee and coordinate sampling and data evaluation as part of long term monitoring.

4.1.10 Cost

Cost estimates are developed according to *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (USEPA 2000). The levels of detail employed in making these estimates are conceptual but are considered appropriate for differentiating between alternatives. The cost estimates are based on the best available information regarding the anticipated scope of the respective remedial alternatives.

Cost estimates are developed for each remedial action alternative based on the RI data to define the scope of each alternative. Due to the uncertainty in RI/FS data, the accuracy of cost estimates is less than estimates developed later in the design phase. The types of costs estimated include the following: (1) Capital costs, including both direct and indirect costs (2) Annual operations and maintenance costs; and (3) Net present value of capital and O&M costs (40 CFR 300.430 (e)(9)(iii)(G)). Remedial action alternative cost estimates for the detailed analysis are intended to provide a measure of total resource costs over time (“life cycle costs”) associated with any given alternative. Cost estimates are developed with expected accuracy ranges of -30 to +50 percent.

Capital Costs: Capital costs are expenditures required to construct each alternative. They are exclusive of costs required to operate or maintain the remedial action throughout its lifetime. Capital costs, direct and indirect, consist primarily of expenditures initially incurred to build or install the alternative. Direct capital costs include all labor, equipment, and material costs, associated with activities such as mobilization/demobilization; monitoring; site work; installation of dredging, containment, or treatment systems; and disposal. Indirect capital costs include contractor markups such as overhead and profit and expenditures for professional/technical services that are necessary to support construction and installation of the remedial action.

Annual Operation and Maintenance (O&M) Costs: These are post-construction costs necessary to ensure or verify the continued effectiveness of each remedial alternative. These costs are estimated on an annual basis and include all labor, equipment, and material costs, and monitoring. Annual O&M costs also include expenditures for professional/technical services necessary to support O&M activities.

Periodic Costs: These costs occur only once every few years (such as 5-year reviews and equipment replacement) or expenditures that occur only once or a few times during the entire O&M period or remedial time frame (such as at site closeout or remedy component repair/replacement). These costs may be either capital or O&M costs, but because of their periodic nature, it is more practical to consider them separately from other capital or O&M costs in the estimating process.

Present Value Cost: The present value cost represents the amount of money that, if invested in the initial year of the remedial action at a given discount rate, would provide the funds required to make future payments to cover all costs associated with the remedial action over its planned life. Future O&M and periodic costs are included and discounted (reduced) by the appropriate present value discount rate over the period of analysis selected for each alternative. The present value was calculated based on a seven percent discount rate as recommended in *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (USEPA 2000). Also, per guidance, inflation and depreciation are not considered in preparing the present value costs.

The alternatives retained for detailed analysis all have containment components and thus have indefinite project durations and likely require perpetual maintenance. The assumed period of analysis used to develop estimates of present value costs for each alternative is 30 year, although 100 years was also evaluated since the costs of maintaining the caps will continue in perpetuity.

A “no-discounting” scenario is also included for the present value analysis of each alternative as recommended by the guidance for long-term projects (for example, project duration exceeding 30 years). A non-discounted constant dollar cash flow over time demonstrates the impact of a discount rate on the total present value cost and the relative amounts of future annual expenditures. Non-discounted constant dollar costs are presented for comparison purposes only and should not be used in place of present value costs in the Superfund remedy selection process.

To support the detail analysis and evaluation of remedial alternatives, a sensitivity analysis was also performed within the cost estimate for each alternative to determine those costs that have the greatest impact on the overall cost (see Appendix G).

4.1.11 State Acceptance and Tribal Consultation and Coordination

4.1.11.1 State Acceptance

This criterion provides the government of the state where the project is located with the opportunity to assess technical or administrative issues and concerns regarding each of the alternatives. It also provides whether the State concurs with EPA’s preferred alternative. State acceptance is not addressed in this FS but will be addressed in the ROD. Input and review of major RI/FS documents by the State of Oregon was sought and considered throughout the development of the FS.

4.1.11.2 Tribal Consultation and Coordination

Although not part of the NCP criteria, under current EPA policy[1], EPA consults and coordinates with Tribes, when appropriate throughout the Superfund process. EPA has been coordinating, throughout this FS, with the six federally recognized tribes[2]. In addition to the ongoing coordination, under EPA's policy, parallel to the State, the Tribes will be given the opportunity to provide technical and administrative issues and concerns regarding each of the alternatives. EPA will also formally consult on the remedy decision, if formal consultation is requested by any of the Tribes.

4.1.12 Community Acceptance

The alternatives evaluated in this FS and the preferred remedy that will be identified in the Proposed Plan will be presented to the public. Based on comments received during the public comment period, community acceptance will be considered and addressed in the ROD. Issues raised by the community will be discussed and addressed in the Responsiveness Summary Section of the ROD. Input from the public, potentially responsible parties and interested stakeholders was sought and considered throughout development of the FS. This occurred through monthly Community Advisory Group (CAG) meetings, meetings with the LWG, in ListServ notices, publication of information on the project website, and other activities consistent with the Community Involvement Plan (USEPA and ODEQ 2002).

4.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

4.2.1 Alternative A: No Action

4.2.1.1 Overall Protection of Human Health and the Environment

Alternative A would not be protective of human health and the environment. Under this alternative, the resuspension of contaminated sediments in the site would continue to impact surface sediments, surface water, and biota and pose unacceptable risks to human health and the environment. Direct contact carcinogenic risks are estimated to be less than 4×10^{-4} (**Figure 4.2-1**). Carcinogenic risks associated with consumption of contaminated fish and shellfish (RAO 2) are less than 4×10^{-2}; the majority of the risk is between RM 6 and 10, and at RM 11, as presented on **Figure 4.2-2**. The estimated child non-cancer hazard is 590, primarily from PCBs and dioxins/furans, as shown on **Figure 4.2-3a-j**. Non-cancer hazard to nursing infants is estimated at 210,000, primarily from PCBs and dioxins/furans (**Figure 4.2-4a-g**). Ecological HQs exceed 1 for both RAO 5 and 6, as presented on **Figures 4.2-5a-k** and **4.2-6a-i**, respectively. Ecological HQs

[1] EPA Policy on Consultation and Coordination with Indian Tribes, May 4, 2011. Incorporates the Executive Order 13175 "Consultation and Coordination with Indian Tribal Governments", November 2000 and Presidential Memorandum, November 5, 2009.

[2] Tribal governments that have met the statutory requirements of the NCP (300.515(b)) and have signed an MOU with EPA.

associated with RAO 5 are less than 100 for BEHP (32), chlordanes (2), DDx (77), lead (3), mercury (2), PAHs (27) and PCBs (84). Hazard quotients associated with RAO 6 are less than 150, primarily for 4,4´-DDE (34), PCBs (17), HxCDF (84), PeCDF (92), TCDD (2), and TCDF (138).

Because no action is taken, Alternative A would result in minimal reductions in COC concentration and related residual risks. Natural recovery process would result reduction in the COC concentrations over time, but are unlikely to achieve all PRGs for COCs or meet all RAOs in a reasonable time frame. The Oregon Health Authority (OHA) would likely continue the fish consumption advisories already in place under State legal authorities. However, the existing advisories might not be sufficiently effective in protecting human health since despite their presence, there is no prohibition from consuming the fish and the current rate of one meal per month for the general population may not be sufficiently protective of fishers. In addition, consumption advisories are ineffective in reducing risk to ecological receptors.

4.2.1.2 Compliance with ARARs

Alternative A does not comply with chemical-specific ARARs identified for the Site since no further action would be taken to address the contaminated media and risks posed by contaminated media. Under this alternative, location-specific and action-specific ARARs would not be triggered.

Compliance with Chemical-Specific ARARs

No further action would be taken to reduce concentrations of contaminants of concern (COCs) in contaminated media. Key chemical-specific ARARs are:

- Numeric human health and aquatic life water quality criteria set forth in OAR Part 340, Division 41, state-wide criteria and any numeric criteria specific to the Willamette Basin, as enacted through the Water Pollution Control Act ORS 468B.048 and any more stringent national recommended water quality criteria established under Section 304(a) of the Clean Water Act, 33 USC §1314;
- Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act, 42 USC 300f, 40 CFR Part 141, Subpart O, App. A. 40 CFR Part 143; and
- Cancer and non-cancer risk standards for degree of cleanup required for hazardous substances set forth in Oregon Environmental Cleanup Law ORS 465.315(b)(A) and Oregon Hazardous Substance Remedial Action Rules OAR 340- 122-0040(2)(a) and (c), 0115(2-4).

Chemical-specific ARARs for surface water quality and groundwater quality discharging to the river would not be met. Additionally, the state standards for the degree of cleanup required by remedial actions for both cancer and non-cancer risks would not be achieved. Thus, this criterion would not be met.

Compliance with Location-Specific ARARs

Location-specific ARARs would not be triggered since no new remedial measures would be undertaken.

Compliance with Action-Specific ARARs

Action-specific ARARs would not be triggered since no new remedial measures would be undertaken.

4.2.1.3 Long-Term Effectiveness and Permanence

Under this alternative no further action and no new controls would be put in place to address the contaminated media. Thus, contaminated media not already addressed as part of the previous actions would be left uncontrolled.

Magnitude of Residual Risk

Alternative A would not address the risks posed by the contamination at the site. The presence of source material in the sediment would limit the ability for natural recovery processes to occur. Reductions in COC concentration and related risks are expected to occur over time, but the RAOs would not be achieved in a reasonable time frame. Residual risk would be greatest with this alternative.

Adequacy and Reliability of Institutional and Engineering Controls

There are no engineering or institutional controls under this alternative; however fish consumption advisories currently issued by OHA would continue. Studies show that the existing advisories are not sufficiently effective in protecting human health since, despite their presence, some anglers still eat their catch and bring their catch home for their families to eat (May and Burger, 1996; Burger et al, 1999; Kirk-Pflugh et al, 1999 and 2011). In addition, consumption advisories are ineffective in reducing risk to ecological receptors.

4.2.1.4 Reduction in Toxicity, Mobility and Volume through Treatment

Under Alternative A, no actions would be taken. Reduction of COC concentrations in sediments would occur only through natural processes. In addition this alternative does not include monitoring to confirm such reductions. Under this alternative there would be no reduction of toxicity, mobility or volume of contaminants through treatment.

Treatment Processes Used

No treatment processes will be used with this alternative.

Amount Destroyed or Treated

No amount of contaminants will be destroyed or treated.

Reduction of Toxicity, Mobility or Volume

There is no reduction of toxicity, mobility or volume with this alternative.

Irreversible Treatment

No irreversible treatment will occur with this alternative.

Type and Quantity of Residuals Remaining After Treatment

Contaminated sediments will remain.

4.2.1.5 Short-Term Effectiveness

Alternative A assumes no construction activities. Therefore, there are no short-term risks to the community, workers, or the environment from implementation of this alternative. Risks to the community and environment would continue as a result of exposures to the contaminated media.

Community Protection

As Alternative A assumes no construction activities, there no risks to the community associated with implementation. There are continued risks to the community through ongoing exposures to contamination, fish consumption advisories currently issued by OHA would continue under this alternative.

Workers Protection

Since no construction is planned, there are no potential impacts to workers.

Environmental Impacts

Since no construction is planned, there are no environmental impacts associated with implementing this alternative. However, environmental impacts would continue due to ongoing exposures to contaminants left in place.

Time until Action Complete

No construction activities would occur under this alternative and the time until RAOs are attained through natural recovery processes is uncertain. However, some PRGs are currently met in some areas of the site as noted below.

RAO 1

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-7a-h**. The SDU SWAC concentrations in **Tables 4.2-1** and **4.2-2** were also used for this evaluation. The SDUs where PRGs are met for this RAO are presented in **Table 4.2-3**. The PRGs for PeCDD and TCDD are met under this alternative.

RAO 2

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-8a-l**. The SDU SWAC concentrations in **Tables 4.2-1** and **4.2-4** were also used for this evaluation. The SDUs where PRGs are met for this RAO are presented in **Table 4.2-5**.

<u>RAO 5</u>
The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-9a-o** The SDU SWAC concentrations in **Tables 4.2-1** and **4.2-6** were also used for this evaluation. The SDUs where PRGs are met for this RAO are presented in **Table 4.2-7**. The PRGs for cadmium, dieldrin, and TBT are met under this alternative.

<u>RAO 6</u>
The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-10a-h**. The SDU SWAC concentrations in **Tables 4.2-1** and **4.2-8** were also used for this evaluation. The SDUs where PRGs are met for this RAO are presented in **Table 4.2-9**. The PRG for DDx is met under this alternative.

4.2.1.6 Implementability

There are no implementability issues associated with this alternative.

Ability to Construct and Operate

No construction or ongoing operations would be conducted.

Ease of Doing More Action, if Needed

May require future ROD amendment if conditions warrant CERLA actions.

Ability to Monitor Effectiveness

Monitoring is not required under Alternative A.

Ability to Obtain Approvals and Coordinate with Other Agencies

No approvals are necessary for implementing this alternative.

Availability of Specialists, Equipment and Materials

No services, equipment, and materials are required.

Availability of Technologies

Technologies to address contaminated media are not required.

4.2.1.7 Cost

There are no costs associated with this alternative.

4.2.2 Alternative B

4.2.2.1 Overall Protection of Human Health and the Environment

Alternative B, in conjunction with MNR and institutional controls, is expected to be protective of human health. Alternative B would address the unacceptable risks to human health through capping, dredging, in-situ treatment and EMNR of 200 acres of contaminated sediments and 9,600 lineal feet of riverbank. The construction duration for this alternative is estimated to be 4 years, with no additional time required to complete dredged material processing.

Reduction in SWACs on a site-wide basis for Alternative B following construction as compared to Alternative A (does not consider MNR) for the focused COCs are as follows:

- PCBs – 42 percent
- Total PAHs – 77 percent
- DDx – 61 percent
- TCDD – 37 percent
- PeCDD – 24 percent
- PeCDF – 89 percent

Concentrations of other COCs would also be reduced in surface sediment under this alternative.

Direct contact carcinogenic risks are estimated to be less than 5 x 10^{-5} (**Figure 4.2-1**), which is within the acceptable risk range. Carcinogenic risks associated with consumption of contaminated fish and shellfish (RAO 2) are less than 3 x 10^{-3}; the majority of the risk is between RM 6 and 8, as presented on **Figure 4.2-2**. The estimated child non-cancer hazard is 68, primarily from PCBs and HxCDF, as shown on **Figure 4.2-3a-j**. Non-cancer hazard to nursing infants is estimated at 15,000, primarily from PCBs and dioxins/furans (**Figure 4.2-4a-g**). Further reductions in risk and hazards are expected through natural recovery processes (MNR) and implementation of institutional controls, although the timeframe for achieving RAOs is uncertain. Fish consumption advisories would be required until such time as RAO 2 is achieved. Outreach would be conducted to educate the public about the fish consumption advisories. Informational materials and surveys of fish consumption patterns will be needed and evaluated to determine advisory effectiveness.

Following the implementation of Alternative B, ecological HQs exceed 1 for both RAO 5 and 6, as presented on **Figures 4.2-5a-k** and **4.2-6a-i**, respectively. Ecological HQs associated with RAO 5 are less than 30 for BEHP (28), DDx (4), lead (2), PAHs (2) and PCBs (4). There are a substantial number of locations where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction as shown on **Figure 4.2-11**. Hazard quotients associated with RAO 6 are less than 10, primarily for 4,4´-DDE (9), PCBs (5), HxCDF (5), PeCDF (5), and TCDF (8). The overall area left to natural recovery processes is less than for Alternative A; however, the degree and timeframe in which these benthic risk areas might recover is uncertain. Further risk reductions are likely to occur over time due to natural recovery processes, and the likelihood of achieving RAOs 5 and 6 within a reasonable timeframe are greater than for Alternative A. Due to the limited exceedances of ecological hazard indices and the relatively low magnitude of these exceedances, natural recovery process is expected to achieve protection of ecological receptors.

Alternative B has a greater likelihood of achieving RAOs 3 and 7 than under Alternative A. Because this alternative focuses on containing or removing the highest contaminant concentrations at the site through capping, dredging, in-situ treatment and EMNR it is expected that there will be substantial reductions in contaminant flux from the surface sediment to the surface water and subsequently surface water and fish tissue concentrations. However, these reductions may not be sufficient in a reasonable time frame.

Residual risks will remain in areas of contaminated riverbanks and groundwater plumes that are not otherwise addressed by capping, dredging, in-situ treatment and EMNR. Although contaminated riverbank soils do not necessarily pose exposure risks to humans or environmental receptors, remaining contamination does pose a recontamination potential and thus could pose residual risks to aquatic receptors. Placement of reactive caps in locations of contaminated groundwater flux would reduce the exposure to those contaminants and assist in attainment of RAOs 4 and 8. However, the extent of the caps may not be sufficient under this alternative to deal with the extent of the groundwater plumes expressing in the sediment.

Alternative B has a greater likelihood of achieving RAO 9 than under Alternative A due to removal of contaminated riverbank materials and placement of either an armored or engineered cap using beach mix or vegetation. However, the extent excavation and capping under this alternative may not be sufficient to deal with the extent of the contamination in riverbank soils that may recontaminate the river sediments.

Resuspension/release during construction activities will be addressed through operational best management practices (BMPs) and engineered control measures. Institutional controls to restrict land uses, such as, Waterway Use Restrictions or Regulated Navigation Areas (RNAs) or environmental easements and equitable servitudes, would be implemented to ensure residual risks are contained within the capped areas. Additionally, coordination with federal and state regulatory authorities on future permitting actions that may affect caps or other remediated areas would likely be needed. The reliance on MNR to further reduce residual risks increases based on how much of the contamination is addressed by capping, dredging, in-situ treatment and EMNR. Thus, for Alternative B the magnitude of the residual risks remaining are largest, and achieving final cleanup levels depends on the effectiveness of MNR and adherence to ICs. Operation and maintenance activities, ICs and monitoring will be implemented to enhance the adequacy and reliability of caps, residual management layers and EMNR. Caps would be monitored and maintained in perpetuity.

4.2.2.2 Compliance with ARARs

Alternative B would comply with ARARs. Chemical specific ARARs would be met over time through implementation of a combination of in-river remedial technologies. Location-specific ARARs for the remedy would be addressed during design and implementation of the alternative. Action-specific ARARs would be achieved by meeting all of the substantive requirements during design, construction, implementation, and monitoring of the alternative.

Compliance with Chemical-Specific ARARs

Key chemical-specific ARARs are:

- Numeric human health and aquatic water quality criteria set forth in OAR Part 340, Division 41, state-wide criteria and any specific numeric criteria for the Willamette Basin, as enacted through the Water Pollution Control Act ORS 468B.048 and any more stringent national recommended water quality criteria established under Section 304(a) of the Clean Water Act, 33 USC §1314;
- Non-zero Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs) established under Safe Drinking Water Act, 42 USC 300f, 40 CFR Part 141, Subpart O, App. A. 40 CFR Part 143; and
- Cancer and non-cancer risk standards for degree of cleanup required for hazardous substances set forth in Oregon Environmental Cleanup Law ORS 465.315(b)(A) and Oregon Hazardous Substance Remedial Action Rules OAR 340- 122-0040(2)(a) and (c), 0115(2-4).

Implementation of the alternative in conjunction with adequate upland source control measures over time are not expected to cause or contribute to exceedances of numeric human health and aquatic life water quality criteria and drinking water MCLGs and MCLs. Oregon’s risk standards for degree of cleanup for hazardous substances will be met over time through implementation of remedial technologies, ICs, and monitoring. Because this alternative relies more heavily on MNR to achieve PRGs and RAOs, the timeframe for compliance with chemical-specific ARARs for all COCs in surface water will be longer compared to other alternatives that rely more on capping and dredging to address contamination. Long-term monitoring and maintenance of engineering controls, pore water, and surface water would ensure that chemical specific ARARs are being met.

During implementation of this alternative potential short-term exceedances of some water quality criteria are possible. Under state law, OAR 340-048-0015 and OAR 340-041-004, short term degradation is allowable if the benefits of the lowered water quality outweigh the environmental costs of the reduced water quality as determined through an analysis of the specific water quality impacts and the development of a water quality monitoring plan during design. Through the analysis of the activity and in the water quality monitoring plan, EPA needs to determine that the activity will be conducted in a manner which will not violate applicable water quality standards beyond the specified short-term degradation period and contain the conditions determined to be necessary or desirable with respect to the discharge (also see Section 401 and implementing regulations of the Clean Water Act). Compliance with water quality criteria will be met through application of the conditions placed on the discharge as specified in the water quality monitoring plan at a specified distance from the remedial operation. Examples of the types of conditions that will be required are: the use of BMPs, engineering controls and monitoring that will primarily seek to minimize sediment resuspension and dissolved chemical dispersion during dredging and capping activities.

Compliance with Location-Specific ARARs

Location-specific ARARs for the remedy would be addressed during design and implementation of the selected remedy. Key location-specific ARARs include but are not limited to:

- Endangered Species Act (ESA) specified under 16 USC 1536 (a)(2);
- Federal Emergency Management Act regulations specified under 44 CFR 9;
- Essential fish habitat as established under Magnuson-Stevens Fishery Conservation and Management Act, 50 CFR Part.600.920; and
- Presence of archaeologically or historically sensitive areas as established under the Native American Graves Protection and Reparation Act, 25 USC 3001-3013, 43 CFR 10.
- The presence of archaeologically or historically sensitive areas as established under the Indian Graves and Protected Objects ORS 97.740-760.
- National Historic Preservation Act (NHPA) and Archaeological Objects and Sites

ESA

ESA requires that the remedial action may not jeopardize the continued existence of endangered or threatened species or result in the adverse modification of species' critical habitat. Agencies are to avoid jeopardy or take appropriate mitigation measures to avoid jeopardy. The substantive requirements of this ARAR would be met during design, construction and long-term monitoring of the alternative.

Compliance with ESA would be met through preparation of a Site-wide Biological Assessment (BA). The BA will evaluate the effects to species listed as threatened or endangered under ESA found at the site and those species' designated critical habitat from the proposed remedial activities and how such impacts will be mitigated and reduced. The BA will determine whether the dredging, capping, and other in-river technologies, EMNR, MNR may adversely affect listed species and propose BMPS and other mitigation measures to minimize the impacts to the species and critical habitat during construction of the remedy as well as mitigation that may be necessary to compensate for impacts to critical habitat. Long-term monitoring of the compensatory mitigation to assure it is functioning as designed will be required. The BA will be provided to the Services (National Marine Fisheries Service [NMFS] and U.S. Fish and Wildlife Service [USFWS]) for their coordination and concurrence. As remedial design progresses there likely will be a need to supplement the site-wide BA to address specific issues unique to remedy implementation at a particular area within the site. If remedial activities may result in any take, a take permit will be requested from the Services. The BA will also serve as a resource document for concurrent Essential Fish Habitat (EFH) coordination with NMFS in compliance with the Magnuson-Stevens Fishery

Conservation and Management Act (Magnuson-Stevens Act) and coordination under the Fish and Wildlife Coordination Act.

Federal Emergency Management Act

These regulations at 44 CFR 9 sets forth the policy, procedure and responsibilities to implement and enforce Executive Orders 11988 (Management as Floodplain), as amended by 13690 and 11990 (Protection of Wetland). The substantive requirements of this ARAR would be met during design and implementation of the alternative. In order to comply with Federal Emergency Management Act, the alternative will need to be analyzed and designed to achieve the following issues:

- Minimize the use of remedial process options that result in a net increase of fill material placed within the river and adjoining flood plain.
- Perform detailed modeling to demonstrate that the alternative does not result in unacceptable flood rise.
- The use of natural features and nature-based approaches in the implementation of the alternative.
- Placement of structures at a higher vertical elevation to address current and future flood risks.
- The floodplain and corresponding elevations would be determined using these approaches:
    - Flood Rise: The evaluation of flood rise will need to consider 500-year flood elevation and freeboard and be based on the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science.
    - Channel Depth: The Willamette River currently has an authorized channel depth of -40 feet Columbia River Datum (CRD). Prior to listing of the Portland Harbor Superfund Site on the National Priorities List (NPL), the USACE proposed deepening the federally maintained navigation channel to -43 feet CRD. Deepening the navigation channel may mitigate the effects of cap and thick layer sand cover placement on flood rise associated with the sediment cleanup.
    - Climate Change: In general, climate change is expected to result in increased winter flow, decreased summer flow and lower snow packs. River flows within the Willamette River watershed are predicted to be higher in the winter, lower in the summer and with an earlier peak flow. In addition, because of a lower snow pack and more frequent fall and winter rain events, more high flow events are expected but of less magnitude than the large flood events observed in the 1900s. Uncertainties associated with potential climate change will be incorporated into the flood rise evaluation.

Native American Protected Objects and Graves Protection Preparation

During the RI, a cultural resource analysis was conducted and it concluded that there are possible archeological artifacts at the site, but no gravesites were noted. EPA would meet the substantive requirements of this ARAR during implementation of the alternative in coordination and consultation with the relevant Tribes. If Native American cultural items or gravesites are present on a property, an inventory of such items would be compiled and items would be returned to the Tribes.

If removal of cairn, burial, human remains, funerary objects, or other sacred objects takes place, re-interment will occur under the supervision of the appropriate Indian tribe. Proposed excavation by a professional archaeologist of a Native American cairn or burial requires written notification to the State Historic Preservation Officer and consultation with the appropriate Indian tribe.

National Historic Preservation Act (NHPA) and Archaeological Objects and Sites

The substantive requirements of this ARAR would be met during design and implementation of the alternative. If cultural resources on or eligible for the national register are present, it will be necessary to determine, in consultation with the appropriate State Historic Preservation Office, if there will be an adverse effect to the resource and, if so, how the effect may be minimized or mitigated. The unauthorized removal of archaeological resources from public or Indian lands is prohibited. A professional archaeologist must conduct any archaeological investigations at a site.

Compliance with Action-Specific ARARs

Action-specific ARARs for the remedy would be addressed during implementation. Key action-specific ARARs include but are not limited to:

- Section 404 of the Clean Water Act and the 404(b)(1) guideline regulations;
- Oregon Water Quality Standards (WQS), Clean Water Act Sections 401 and 402;
- Rivers and Harbors Act, Section 10, 33 USC Section 403. 33 CFR Section 322(e), 33 CFR Section 323.3 and Section 323.4(b) and (c);
- Resource Conservation and Recovery Act (RCRA) and implementing regulations;
- Hazardous Waste and Hazardous Materials II. ORS 466.005(7) OAR 340-102-0011 - Hazardous Waste Determination;
- Hazardous Waste and Hazardous Materials II. Identification and Listing of Hazardous Waste OAR 340-101-0033;
- State of Oregon Solid Waste (ORS459.0015, ORS 459.015, and OAR 340-093 through 340-095);

- Toxic Substances Control Act, 15 USC §2601 et seq., 40 CFR Part 761.60-761.79.

<u>CWA 404</u>

The requirements of the CWA Section 404 and 404(b)(1) guidelines apply to selecting in-water disposal sites and evaluating impacts and compensatory mitigation for unavoidable impacts from dredging, covering, capping. The 404(b)(1) guidelines provide standards for the designation, construction and monitoring of in-water disposal sites and in-water filling activities in the Willamette River, and require that no such disposal shall jeopardize the existence of a listed species under the Endangered Species Act. A simplified approach was used that assumed armored and reactive caps within shallow water areas and riverbanks would result in unavoidable impacts that would require compensatory mitigation. This approach is presented in Appendix J.

The alternative would meet all of the substantive requirements of this ARAR during design, construction, and long-term monitoring. Full compliance with CWA 404(b)(1) includes preparation of a 404(b)(1) evaluation document to determine the potential impacts of the activities performed under this alternative on waters and wetlands, as well as opportunities to mitigate any unavoidable adverse impacts to those aquatic resources. Through the 404(b)(1) analysis, controls will be required for construction activities to minimize the impacts. Even with implementation of avoidance and minimization efforts, it is anticipated that remediation of the Site will result in unavoidable loss of some aquatic habitat. These losses will be offset by compensatory mitigation, which entails the restoration, establishment, enhancement, and/or preservation of wetlands, streams, or other aquatic resources conducted specifically for the purpose of offsetting authorized impacts to these resources. A compensatory mitigation framework will be developed which, in coordination with NMFS and USFWS, may use a Habitat Equivalency Analysis (HEA) method, Relative Habitat Value (RHV) scoring approach, or other approach for determining compensatory mitigation acreages.

The substantive requirements of the CWA Section 404 trigger the need to consider the substantive requirements of the CWA Section 401 and Oregon’s Water Quality law. Pertinent water quality-specific information would be considered during design and a water quality monitoring plan will be developed to include conditions on the activities to be met such as, but not limited to, dredging speeds and techniques, establishing a point of compliance for water quality criteria, type and frequency of monitoring samples, storm water management and treatment, erosion control measures, seasonal constraint, and restoration/mitigation measures.

Both CWA Section 401 and Oregon’s Water Quality Law require that any activity during the implementation of the remedial action that may result in a discharge to waters of the State requires reasonable assurance that water quality standards will be complied with and requires conditions and other requirements deemed necessary to be placed on the discharge. During dredging and cap placement operations, potential short-term exceedances of some water quality criteria are possible. However, through the application of BMPs and engineering control measures water quality criteria will be met in accordance with Section 401 and Oregon's Water Quality Law.

<u>RCRA</u>

The substantive requirements of the RCRA ARAR would be met during design and implementation of the alternative. Analytical testing results of dredged sediment will be used for waste characterization. Initially this will consist of evaluation of remedial investigation data which will then be supplemented with design-level information. The sediment and soil disposal decision tree (**Figure 3.3-40**) is used to guide the process to determine appropriate disposal. A Materials Management Plan will be developed to provide the necessary ARAR compliance documentation.

All dredged materials and contaminated riverbank materials removed from the Site under this alternative would be managed under Disposal Management Method (DMM) Scenario 2 (off-site disposal facilities).

- Compliance with RCRA hazardous waste identification and handling will be met and will include preparation of a Materials Management Plan during design to be used during implementation of remedial actions. The extent of the area containing listed hazardous waste off of the Siltronic/GASCO facilities will be further refined in design. Characteristic hazardous waste will be identified through Toxicity Characteristic Leaching Procedure (TCLP) sampling as allowed by RCRA. Characteristic hazardous waste criteria for toxicity have been established for 10 COCs in sediment as shown in **Table 4.2-10**. The RI data set indicates that six COCs exceed the criteria. The locations where these criteria are exceeded is presented on **Figure 4.2-12**.
- Waste will also be sampled as generated to determine any volumes that exceed Land Disposal Restrictions (LDRs) and will require the prescribed treatment prior to disposal. LDR values have been established for 39 COCs as shown in **Table 4.2-11**. The RI data set indicates that 32 COCs exceed the criteria. The locations where these criteria are exceeded is presented on **Figures 4.2-13a-e.**
- Hazardous waste generated during remedial actions may be treated and temporarily stored at transload facilities pending final transport and disposition. An on-site transloading facility may be used. No hazardous waste will be disposed of onsite. The Materials Management Plan will define record keeping requirements, container requirements, storage requirements consistent with RCRA to be implemented during construction and operation of the transload facilities.

<u>Hazardous Materials Transportation Act:</u>

The substantive requirements of this ARAR would be met during design and implementation of the alternative. A Materials Management Plan will be developed during design detailing compliance with hazardous materials transportation regulations.

Oregon Hazardous Waste and Hazardous Materials:

The substantive requirements of this ARAR would be met during design and implementation of the alternative. State-listed hazardous waste has been identified off the Arkema site. Any dredge material generated from this area or any other area where pesticides are located in sediment or riverbank soil will be tested and handled in accordance with Oregon regulations as shown on **Figure 3.3-40**. This approach would also meet the requirements for management of waste pesticides in OAR 340-109. Hazardous waste generated during remedial actions may be treated and temporarily stored at transload facilities pending final transport and disposition. A Materials Management Plan will be developed as part of design addressing how State treatment and storage regulations will be complied with during the construction and operation of the transload facilities.

Toxic Substances Control Act (TSCA):

The substantive requirements of this ARAR would be met during design and implementation of the alternative. It is anticipated that TSCA waste containing greater than 50 mg/kg of PCBs may be generated as a result of remedial actions in riverbank areas. The Chemical Waste Management Facility in Arlington, Oregon, is permitted to accept TSCA waste (RCRA and TSCA EPA ID Permit ORD089452353). The Materials Management Plan to be prepared during design and utilized during implementation will address proper handling and disposition of any TSCA waste generated during remedial actions. There were no sediment samples that exceeded the TSCA threshold in the RI, so it is anticipated that very little, if any, waste would be generated that would require compliance with this ARAR.

General Emissions Standards and Fugitive Emission Requirements:

The substantive requirements of these ARARs would be met during design and implementation of the alternative. Reasonable precaution to control fugitive emission of air contaminants will be taken in accordance with OAR 340-226. Emission of airborne particulate matter would be controlled to address OAR 340-208. Dust suppression will be maintained to eliminate air contaminant migration during remedial action in compliance with these ARARs.

Marine Mammal Protection Act:

The substantive requirements of this ARAR would be met during design and implementation of the alternative. The selected remedial actions will be carried out in a manner to avoid adversely affecting marine mammals (such as the Steller sea lion).

Migratory Bird Treaty Act (MBTA):

The substantive requirements of this ARAR would be met during design and implementation of the alternative. The selected remedial actions will be carried out in a manner to avoid adversely affecting migratory bird species, including individual birds or their nests (such as the Bald Eagle).

Fish and Wildlife Coordination Act:

The substantive requirements of this ARAR would be met during design and implementation of the alternative. This statute and implementing regulations require coordination with federal and state agencies to ensure that any modification of any stream or other water body affected by any action authorized or funded by the federal agency provides for adequate protection of fish and wildlife resources.

4.2.2.3 Long-Term Effectiveness and Permanence

Under Alternative B, approximately 872,000 cy of contaminated sediments and riverbank soil covering approximately 76 acres of river bottom and 9,600 lineal feet of riverbank would be permanently removed by dredging or excavating to targeted sediment removal depths. Various caps would be placed over 34 acres of the site. Residuals from dredging and contaminated areas subject to EMNR would be managed with a thin layer sand cover at approximately 179 acres. After construction is completed, the remediated areas would no longer pose unacceptable impacts to humans and the environment.

Magnitude of Residual Risk

Reductions in contaminant concentrations, and thus potential exposures and risk, are estimated at the completion of construction. Because contamination within the areas of construction is either removed, covered or treated in-situ, the overall concentrations of contamination available for resuspension is less than under Alternative A. Thus, there is less potential for contamination from source areas to continue to recontaminate other areas of the site and allow for MNR processes to occur. The time needed for MNR to achieve the RAOs is less than the time it would take natural recovery to achieve the same level of protectiveness for Alternative A. In addition, some of the areas where groundwater contamination is discharging to the river will be capped to eliminate or reduce this discharge, which in combination with lower overall contaminant concentrations in surface sediment will decrease the time needed to achieve RAOs 3, 4, 7, and 8. Contaminated material addressed in riverbanks under this alternative will also eliminate sources of contamination that will continue to recontaminate the site and decrease the time needed to achieve RAO 9.

The residual risks for each RAO are as follows:

RAO 1 – Estimated post-construction cancer risks shown on **Figure 4.2-1** are generally less than 5×10^{-5}, which is within EPA's acceptable risk range, but greater than the estimated background risk of 3×10^{-6} in several areas.

RAO 2 – Estimated post-construction cancer risks shown on **Figure 4.2-2** are 3×10^{-3}; the majority of the risk is between RM 6 and 10. The estimated risks are greater than the upper end of the acceptable risk range and the estimated background risk of 7×10^{-5} throughout the main river channel. Residual risks within Swan Island Lagoon would be at the upper end of the acceptable risk range. The estimated post-construction child non-cancer hazards are shown on **Figure 4.2-3a-j** and are less than 68, primarily from PCBs and HxCDF. Post-construction infant non-cancer hazards are generally less than 15,000, primarily from PCBs and dioxins/furans as shown on **Figure 4.2-4a-g**.

RAO 5 **–** The estimated ecological residual risk at the completion of construction is presented on **Figures 4.2-5a-k.** Post-construction exposures for ecological receptors resulting in a HQ greater than 1 would still exist in localized areas throughout the site. Ecological HQs associated with RAO 5 are less than 30 for BEHP (28), DDx (4), lead (2), PAHs (2) and PCBs (4). There are a substantial number of locations where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction (**Figure 4.2-11**). The overall area left to natural recovery processes is less than for Alternative A. However, the degree to which the benthic risk areas not addressed by this alternative, and the timeframe in which they might recover is uncertain.

RAO 6 **–** The estimated ecological residual risk at the completion of construction is provided on **Figures 4.2-6a-i.** Post-construction exposures to ecological receptors through dietary exposure would result in less than 10, primarily for 4,4´-DDE (9), PCBs (5), HxCDF (5), PeCDF (5), and TCDF (8).

Adequacy and Reliability of Engineering and Institutional Controls

Sediment removal, capping, and thin layer covers are reliable and proven technologies as long as they are designed for the appropriate environmental and anthropogenic conditions. Offsite thermal destruction (incineration) and land-based disposal facilities are in operation and have proven to be reliable technologies.

Alternative B would be effective in limiting exposure to risks posed by COCs in the sediments and riverbank soils provided the integrity of the caps is maintained. Therefore, the caps would need to be monitored and maintained in perpetuity. Reviews at least every five years, as required, would be necessary to evaluate the effectiveness of any of these alternatives because hazardous substances would remain on-site in concentrations above levels that allow for unlimited use and unrestricted exposure.

Operation and maintenance activities, ICs and long-term monitoring will be implemented to assure protectiveness and reliability of caps and thin layer covers. The following paragraphs further describe how these activities maintain the protectiveness and reliability of these controls:

- O&M will be required for material left in place and may include bathymetric surveys and diver performed monitoring at regular intervals to confirm the thickness of thin layer sand covers and capping materials. In addition to regular surveys, supplemental surveys will be performed following episodic natural) and anthropogenic events that have the potential to disturb caps and sand covers.

- ICs include governmental controls, proprietary controls and informational devices. The reliability of institutional controls ICs can be enhanced through activities such as regular inspection of buoys and other devices to delineate regulated navigation areas, administrative procedures and inspections to ensure the maintenance of co-located structures and ongoing public outreach efforts to enhance the effectiveness of informational devices. Coordination will need to occur with federal and state regulatory authorities during future permitting activities that may disturb subsurface contaminated sediment or capped areas. Additional institutional controls (see Table 2.4-2) would be necessary to maintain cap integrity in perpetuity. Fish consumption advisories, which rely on voluntary compliance, would be enhanced by additional outreach to improve their effectiveness in reducing risk to human health by limiting exposure to COCs.

- Monitoring of the effectiveness of the remedial alternative would include sampling of the water column, sediment, and biota tissue before, during and after construction to verify that risks to the ecosystem continue to decrease. The planned post-construction monitoring program would result in collection of the data necessary to determine whether the fish consumption advisory or other restrictions imposed as part of the remedial action could be relaxed. Tissue PRGs based on the consumption of 19 eight-ounce fish meals per month were developed for use during the post-construction monitoring period to evaluate if contaminant concentrations are decreasing toward PRGs as expected.

4.2.2.4 Reduction in Toxicity, Mobility and Volume through Treatment

Implementation of Alternative B reduces toxicity, mobility and volume through treating sediments and riverbanks where PTW is present or where groundwater plumes are discharging or have the potential to discharge into the sediment and surface water. PTW will be treated in-situ or ex-situ, depending on the technology assignment, while in-situ treatment will be used in areas where groundwater plumes are located.

Treatment Processes Used

Activated carbon or organophilic clay are the representative in-situ treatment technologies that reduce the bioavailable fractions and thus toxicity and mobility of contaminants as measured through pore water concentrations. The delivery mechanisms for activated carbon or organophilic clay include:

- *Broadcast Activated Carbon:* Direct broadcasting of activated carbon onto the sediment surface at 1 pound of carbon per square foot (lb carbon/ft^2)

- *Reactive Caps:* Includes a 12-inch chemical isolation layer comprised of sand mixed with 5 percent activated carbon (0.12 pounds per square foot per centimeter [lbs/ft^2/cm])

- *Reactive Residual Layer:* 12 inches of sand mixed with 5 percent activated carbon (0.12 $lbs/ft^2/cm$)

- *Significantly Augmented Reactive Cap:* Includes a 12-inch chemical isolation layer comprised of sand mixed with 0.48 $lbs/ft^2/cm$ activated carbon and an organoclay layer

PTW that is highly mobile and not reliably contained is identified to be treated ex-situ prior to disposal. All PTW treated ex-situ in this alternative is assumed to be disposed at a RCRA Subtitle C facility. In addition, the Subtitle C disposal facility selected as a representative process option (Chem Waste) uses treatment processes such as cement stabilization or thermal desorption, as needed, to meet LDRs for hazardous waste. Thermal desorption is the representative ex-situ treatment technology.

Amount of Material Destroyed or Treated

Under Alternative B, 83 acres of material would be treated in-situ and 330,000 cy of material would be treated ex-situ.

Reduction of Toxicity, Mobility or Volume

Reduction of toxicity, mobility and volume would be achieved through:

- *Broadcast Activated Carbon:* 7 acres

- *Reactive Caps:* 19 acres

- *Reactive Residual Layer:* 55 acres

- *Significantly Augmented Reactive Cap:* 1.8 acres

In addition, based on the technology assignments for this alternative, the estimated quantity of dredged PTW (source material and not reliably contained) requiring ex-situ treatment is estimated at 330,000 cy. The actual amount of material subject to ex-situ treatment would depend on the results of the waste characterization testing during the remedial design. Thermal desorption reduces the mobility of approximately 39 percent of the dredged material that is PTW. In addition, the mobility of contaminants would be further reduced through sequestration by placing it in a permitted landfill, not due to permanent and irreversible treatment.

For dredged material not subject to ex-situ treatment, mobility would be reduced by placing it into a permitted landfill (through sequestration, not treatment); there would be no reduction in toxicity or volume.

Irreversible Treatment

Activated carbon is not readily broken down in the environment and thermodynamic principles indicate that the bonding of COCs to activated carbon will remain strong over time. COCs are expected to remain bound whether the sorbent and bound chemicals remain in the sediment bed or are re-suspended and transported away from the area (ITRC 2014). As a result, use of activated carbon for in-situ treatment is considered permanent and irreversible as long as there is sufficient quantity of activated carbon to address the amount of contamination present.

Low-Temperature Thermal Desorption is an ex-situ remedial technology that uses heat to physically separate organic contaminants from excavated soils and sediments. Thermal desorbers are designed to heat contaminated sediments to temperatures sufficient to cause contaminants to volatilize and desorb (physically separate) from the sediment. Although they are not designed to decompose organic constituents, thermal desorbers can, depending upon the specific organics present and the temperature of the desorber system, cause some of the contaminants to completely or partially decompose. The vaporized hydrocarbons are generally treated in a secondary treatment unit (such as an afterburner, catalytic oxidation chamber, condenser, or carbon adsorption unit) prior to discharge to the atmosphere. Afterburners and oxidizers destroy the organic constituents. Condensers and carbon adsorption units trap organic compounds for subsequent treatment or disposal.

Solidification/Stabilization adds chemically reactive compounds to dredge materials that form stable solids that are non-hazardous or less-hazardous than the original materials. Solidification refers to the physical changes in the contaminated material when a certain binding agent is added. These changes include an increase in compressive strength, a decrease in permeability, and condensing of hazardous materials. Stabilization refers to the chemical changes between the stabilizing agent (binding agent) and the hazardous constituent. These changes result in a less soluble, less toxic material with hindered mobility. Common bonding agents include, but are not limited to, Portland cement, lime, limestone, fly ash, slag, clay, and gypsum. Because of the vast types of hazardous materials, each agent may be tested/piloted on the site before a full-scale project is undertaken. Most binding agents used are a blend of various single binding agents, depending on the hazardous material. Portland cement has been used to treat more contaminated material than any other solidification/stabilization binding agent because of its ability to bind free liquids, reduce permeability, encapsulate hazardous materials, and reduce the toxicity of certain contaminants. Lime can be used to adjust the pH of the substance of drive off water by the exo-thermic reaction. Limestone can also be used to adjust pH levels.

Type and Quantity of Residuals Remaining After Treatment

Implementation of Alternative B would not address 69 percent of the PTW at the site, consisting primarily of PCBs and dioxins/furans. Therefore, this alternative does not meet the statutory preference for addressing principal threat wastes. There would also be residual PTW that will remain under caps, although the treatment barriers in the caps would be designed to prevent exposure. While 9.6 acres of reactive caps are included in this alternative to deal with exposures from contaminated groundwater plumes, the full extent of exposure from these plumes is uncertain and has not been quantified. Based on the upland evaluations on the nature and extent of these groundwater plumes, this alternative would treat the least amount of contaminated groundwater discharging to the sediment bed at the site. Additional characterization during remedial design would be required to ensure that the full extent of the exposure is addressed in remedy implementation.

4.2.2.5 Short-Term Effectiveness

With the exception of Alternative A, implementation of Alternative B would have the least impact to the community, workers, and the environment during construction. The period of construction (4 years) is shorter and involves handling of the least amount of dredged materials (872,000 cy) and borrow materials (314,000 cy) than other alternatives. However, Alternative B would require the longest time to achieve RAOs, which would mean the longest impacts to the environment. These impacts would include the impact of not consuming the fish and ability of the tribes to fully engage in their ceremonial practices.

Community Protection

There are some short-term risks to the community from exposure to contaminated sediments and riverbank soils during the construction period. This alternative involves dredging of 81 acres and excavation of 9,624 lineal feet of riverbank, with import of approximately 314,000 cy of borrow material. Construction is assumed to proceed 24 hours per day, six days per week, 122 days per year, four years. Construction and operation of a treatment and transport facility may be necessary. Construction and operation activities may result in temporary noise, light, odors, potential air quality impacts and disruptions to commercial and recreational river users on both sides of the river. However, the actual duration at any specific location would be less than the overall construction period.

Off-site disposal may result in upland impacts to the community through increased vehicular traffic (direct transport to off-site disposal or rail transfer facilities) with potential increases in accidents and air-quality issues associated with dust, odor, and vehicular exhaust. Increased barge traffic transporting dredged material may interfere with commercial navigation, increased potential for waterborne accidents, and on-shore impacts from exhaust. Under this alternative, the amounts of dredged and borrow materials for construction that require handling and transport is less than for alternatives D through G.

Measures to minimize short-term risks to the community will be addressed through implementation of health and safety plans and the use of BMPs, including the following:

- Limiting access to sediment processing at upland treatment and transfer facility areas to authorized and trained personnel.

- Pollution controls to minimize emissions and odors from construction activities.

- Engineering and navigation controls (established by the dredging and/or materials management contractor working in coordination with the U.S. Coast Guard and other entities) to mitigate increased river traffic.

- Isolating work areas with an adequate buffer zone so that pleasure craft and commercial shipping can safely avoid construction areas.

- Fish consumption advisories would continue under this alternative until such time as Remedial Action Objectives (RAOs) are achieved. COC concentrations in fish tissue are expected to increase during the course of the multi-year construction period; however, this will mainly occur during the in-water work window of July 1 through October 31. Based on experience at other sites [Hudson River (NY), Grasse River (NY)], recovery following construction is relatively rapid, on the order of a few years, and is expected to continue to decrease as contaminant concentrations in sediment decrease.

Worker Protection

Alternative B would pose potential risks to site workers through:

- Direct contact with COCs in dredged sediment

- Demolition, removal, and/or replacement of structures

- Activities in a river environment such as working on a vessel, near heavy and mobile equipment in and around working docks

- Working around marine operations with frequent vessel traffic

- Transport of borrow materials and carbon amendment for cover construction

- Placing amendments in in-situ treatment areas

- Transport of contaminated sediment and riverbank soils

Overall, the risks associated with this alternative would be less than for alternatives D though G due to the shorter construction period.

Safety measures and BMPs would be used to minimize the impacts referenced above. Measures such as:

- Use personal protective equipment (PPE)

- Establish work zones

- Dust suppression during material handling and riverbank actions

- Worker Health and Safety Plans
- Following Occupational Safety and Health Administration (OSHA) approved health and safety procedures

Environmental Impacts

Sediment removal may result in short-term adverse impacts to the river, including:

- Exposure of fish and other biota to suspended and dissolved contaminants in the water column.
- Temporary loss of benthos and habitat for the ecological community in dredged areas.
- Increased emissions from construction and transportation equipment.

Measures and BMPs would be used to minimize the above referenced impacts, including:

- Engineering controls to minimize resuspension/release during cap placement.
- Sequencing of dredging and placement activities to minimize recontamination potential.
- Conduct work within the in-water work window (July 1st through October 31st) to minimize impacts on the aquatic environment.
- Silt curtains, sheet pile walls, or other physical barriers will be used as appropriate to minimize releases.
- Actions will be taken to remove fish from within barrier enclosures prior to commencing construction activities.

Precautions and controls will be taken to prevent incidental and accidental discharges of toxic materials from entering the water column from in-water work. These include:

- Use spill plates and aprons to prevent dropping dredge material into the water
- Reduction of cycle times.
- Restrict lateral movement of the dredge bucket while under water.
- Use closed dredge buckets whenever site conditions allow.
- Reduce or stop dredging during periods of peak current.

Application of emissions reduction strategies to reduce short-term impacts posed to the environment and promotes technologies and practices that are sustainable according to the EPA Region 10 Clean and Green Policy. Emission reduction could be controlled through BMPs such as:

- Use of reusable energy sources.
- Limit idling of trucks and equipment.
- Rely on local sources of materials.
- Ensuring that trucks, barges and railcars are full prior to transport
- Implement onsite dust and noise control to reduce air pollutant and greenhouse gas emissions.
- Require clean fuel incentives in construction contracts.

Environmental impacts would continue until RAOs are achieved. Environmental impacts to human health via consumption would be controlled through fish consumption advisories.

Time until Action Complete

Construction operations for this alternative are estimated to take four years. Following the estimated construction time, Alternative B would take the longest time to meet RAOs and PRGs, as the residual contaminant concentrations would be the greater than Alternative B through G, requiring more time for MNR processed to achieve the RAOs and success would be more uncertain. However, some PRGs are met under this alternative and others are met in some areas of the site at the completion of construction, as discussed below. In the tables presenting the SDUs where the PRGs are met, a black 'X' indicates the PRGs were met under Alternative A and a red 'X' indicates the PRGs met under Alternative B. Blank cells indicate that the PRG is not met in that SDU.

RAO 1

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-7a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-2** were also used for this evaluation. The SDUs where PRGs are met for this RAO are presented in **Table 4.2-12**. In addition to the PRGs met under Alternative A, the PRGs for PCBs, HxCDF, PeCDF, and TCDF are met under this alternative.

RAO 2

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-8a-l**. The SDU SWAC concentrations in **Tables 4.2-1** and **4.2-3** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-13**.

RAO 5

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-9a-o**. The SDU SWAC concentrations in **Tables 4.2-1** and **4.2-6** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-14**. In addition to the PRGs met under Alternative A, the PRGs for chlordanes, mercury, and zinc are met under this alternative.

RAO 6

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-10a-h**. The SDU SWAC concentrations in **Tables 4.2-1** and **4.2-8** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-15**. In addition to the PRG met under Alternative A, the PRGs for PeCDD and TCDD are met under this alternative.

4.2.2.6 Implementability

Alternative B would be readily implementable from both the technical and administrative standpoints. The in-river remedial action as envisioned in this FS can be constructed, operated, and maintained within the site-specific and technology-specific regulations and constraints.

Ability to Construct and Operate

The in-river construction activities required for the implementation of Alternative B would be technically feasible and have been implemented at many Superfund sites around the country. Implementation of Alternative B would involve dredging 462,000 cy of sediment and the handling and placement of 314,000 cy borrow material. These volumes are less than would be required for Alternatives D though G. This alternative also has the shortest project duration for construction. Alternative B would present the least challenge to implement.

Alternative B has a construction period of approximately four years, involves construction activities within 200 acres, and thus has a low potential for technical difficulties that could lead to schedule delays. Portland Harbor is a working industrial waterway that has the necessary infrastructure to support sediment remediation activities. Nevertheless, careful coordination will be required among government agencies, private entities and the community to design, schedule, and construct the cleanup actions. Further, it will be important to evaluate whether upland source control actions have been implemented to a sufficient degree before or as a part of remedy construction to limit recontamination potential.[3]

Inadequate removal of contaminated sediment or the need to manage residuals remaining after dredging could require further evaluation to determine the need for additional actions. Release and residual management measures such as silt curtains and sheet piles may be difficult to construct and reliably operate in portions of the river

[3] If further action under CERCLA is warranted, then a separate decision document would be issued.

affected by navigation traffic, deeper water, and significant current, this may lead to schedule and implementation delays.

Another technical implementability challenge is remediation under piers and other above-water structures. Debris is expected to complicate, but is not likely to significantly delay, construction efforts. The number of obstructions expected to be encountered during construction of this alternative is the smallest compared to the other alternatives. Maintaining flexibility in construction methods through the remedial design phase is an important consideration for these areas.

Ease of Doing More Action, if Needed

Increasing the extent of capping, dredging/excavation, in-situ treatment, or EMNR would be easily implemented. Additional remedial actions on riverbanks could be more problematic due to factors such as adjacent land use, structures, steepness, use of the adjacent waterways, and community concerns. Depending on the scope of the additional actions, amendments to the ROD may be needed.

Ability to Monitor Effectiveness

Monitoring effectiveness in the short- and long-term is relatively straightforward and easy to implement. Inspection, maintenance, and repair/replacement of caps are relatively easy and straightforward to implement in unobstructed areas, but may be more challenging around obstructions, in the navigation channel, or in future maintenance dredge areas. If monitoring should fail to detect a release in areas where waste has been left in place in a reasonable time frame, then a release of COCs to the environment may occur. The risk of this occurring is highest for this alternative since it leaves the most waste in place, commensurate with a lower level of protection.

Institutional controls are a component of all remedial alternatives to manage human health risks from consumption of fish and shellfish in the short and long term. The primary control mechanisms are fish consumption advisories, in conjunction with public education and outreach programs to enhance awareness end effectiveness of the advisories as a means to reduce exposures to COCs. Fish consumption advisories are not enforceable and are generally understood to have limited effectiveness. One objective of the public education/outreach effort is to improve compliance with the advisories. Institutional controls should therefore be relied upon to the minimum extent practicable. These programs would likely be developed and administered by the responsible parties with EPA and OHA oversight and with participation from local governments, Tribes, and other community stakeholders. In addition, environmental covenants (such as RNAs and land-use restrictions) will be used to protect capped areas where contamination is left in place above levels needed to achieve RAOs and PRGs. Both controls are difficult to monitor. Environmental covenants are difficult to enforce and have administrative costs in the long-term.

MNR requires significant administrative effort over the long term to oversee and coordinate MNR sampling, data evaluation, and future additional actions, if any are needed. Alternative B relies the most on reducing contaminant concentrations through MNR (approximately 2,250 acres) therefore, there is greater uncertainty that RAOs and PRGs will be met in a reasonable timeframe. For this reason, some additional future remedial actions are predicted to be more likely for Alternative B. Should future remedial actions be warranted, subsequent decision documents would be issued.

Ability to Obtain Approvals and Coordinate with Other Agencies

A key administrative feasibility factor for Portland Harbor is that in-water construction is not allowed year round in order to protect migrating salmon in the lower Willamette River. The in-water fish work window established for the Willamette River is July 1 through October 31 and accounts for fish migration patterns. EPA will confirm these in coordination with the National Marine Fisheries Service and U.S. Fish and Wildlife Service.

Coordination with Oregon Department of State Lands (DSL) and/or other property owners would need to be conducted to manage waste left in place and implement land use restriction ICs, if needed. Additionally, property owners of potential staging areas and transloading facilities would also need to be consulted.

Regulatory and facility approval for offsite permitted disposal facilities as identified on **Figure 3.3-40** should be obtainable in a short period of time.

Regulatory approval for demolition, removal, and relocation of structures may be challenging, but should be obtainable.

Institutional controls, such as Regulated Navigation Areas (RNAs) or other land use restriction mechanism, would need to be established for all caps outside the federally regulated navigation channel and future maintenance dredge areas that restrict the following activities within 100 feet of the sediment cap:

- Anchoring, spudding, dredging, laying cable, dragging, trawling, conducting salvage operations, operating commercial vessels of any size, and operating recreational vessels greater than 30 feet in length would be prohibited in the regulated area.

- All vessels transiting or accessing the regulated area should do so at no wake speed or at the minimum speed necessary to maintain steerage.

Coordination with USACE, NMFS, DEQ, and ODFW on future CWA 404 permitting and other regulatory approvals that may disturb areas of known subsurface contamination and caps may be challenging, but should be attainable. This is a typical IC concept used at sediment sites and comes with administrative burdens and costs.

Availability of Specialists, Equipment and Materials

Services, equipment, and materials are locally or regionally available. Since Alternative B requires the least volume of materials, obtaining materials would be the least difficult. Columbia River dredge material is assumed to be commercially available and would be considered as a source of commercial fill material, if it meets the clean fill requirements specified in the ROD. Different modes of transport (barges, trucks and/or rail) for offsite disposal are available. Use of rail would require infrastructure and more coordination than other modes of transport.

Availability of Technologies

Regional upland landfills are authorized to receive contaminated sediment and have done so on several recent projects in or near Portland Harbor. Upland commercial landfills are identified in Section 3.6.3.2 have capacity relative to the volume of sediment expected to be dredged from the Site for Alternative B. The upland commercial landfills can accept wastes transported by rail, barge, or trucking. Transportation and management of materials would involve identification of sufficient space and proximity to the transportation network to the landfill facility. Several potential sites were identified in the Portland Harbor area for construction of a transload facility for handling material for disposal in an upland commercial landfill.

4.2.2.7 Cost

Other than Alternative A, Alternative B has the lowest cost. Total capital costs for this alternative are $703,906,000 over 4 years. Total periodic costs (excluding 5-year reviews) are $337,522,000, and the overall net present value cost is $790,870,000. The 5-year review periodic costs are $308,000 per event, totaling $1,848,000 over 30 years. Additionally, longer-term costs associated with maintenance and monitoring of contaminants contained on site have been evaluated and estimated to be $596,500,000 ($14,560,000 in present value) over an additional 70 years. Detailed costs associated with implementing Alternative B are presented in Appendix G, and are summarized in Table CS-B.

4.2.3 Alternative D

4.2.3.1 Overall Protection of Human Health and the Environment

Alternative D, in conjunction with MNR and institutional controls, is expected to be protective of human health. Alternative D would address the unacceptable risks to human health through capping, dredging, in-situ treatment and EMNR of 265 acres of contaminated sediments and 13,200 lineal feet of riverbank. The construction duration for this alternative is estimated to be 5 years, with no additional time required to complete dredged material processing.

Reduction in surface-area weighted average concentrations (SWACs) on a site-wide basis for Alternative D following construction as compared to Alternative A (without consideration of MNR) for the RAL COCs are as follows:

- PCBs – 53 percent
- Total PAHs – 86 percent
- DDx – 67 percent
- TCDD – 45 percent
- PeCDD – 39 percent
- PeCDF – 91 percent

Concentrations of other COCs would also be reduced in surface sediment under this alternative.

Direct contact carcinogenic risks are estimated to be less than 5 x 10^{-5} (**Figure 4.2-1**), which is within the acceptable risk range. Carcinogenic risks associated with consumption of contaminated fish and shellfish (RAO 2) are less than 3 x 10^{-3}; the majority of the risk is between RM 6 and 8, as presented on **Figure 4.2-2**. The estimated child non-cancer hazard is 50, primarily from PCBs and HxCDF, as shown on **Figure 4.2-3a-j**. Non-cancer hazard to nursing infants is estimated at 12,000, primarily from PCBs and dioxins/furans (**Figure 4.2-4a-g**). Because further reductions in risk are likely to occur from natural recovery processes, Alternative D would require less reliance on fish consumption advisories to attain additional effectiveness than Alternative B.

Following the implementation of Alternative D, ecological HQs exceed 1 for both RAO 5 and 6, as presented on **Figures 4.2-5a-k** and **4.2-6a-i**, respectively. Ecological HQs associated with RAO 5 are less than 30 for BEHP (28), DDx (2), lead (2), and PCBs (2). There are fewer locations under Alternative D than in Alternative B where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction as shown on **Figure 4.2-11**. Hazard quotients associated with RAO 6 are less than 10, primarily for 4,4´-DDE (5), PCBs (3), HxCDF (4), PeCDF (5), and TCDF (7). Further risk reductions are likely to occur over time due to natural recovery processes, and the likelihood of achieving RAOs 5 and 6 within a reasonable timeframe are greater than for Alternative B.

Alternative D would achieve RAOs 3 and 7 in a shorter period of time than Alternative B because lower contaminant sediment concentrations are left remaining outside constructed areas, reducing flux to surface water.

The area covered by reactive caps in locations of contaminated groundwater under Alternative D is greater than for Alternative B, reducing the residual risks and the time needed to attain RAOs 4 and 8.

Alternative D has a greater likelihood of achieving RAO 9 than under Alternative B due to additional removal of contaminated riverbank materials and placement of either an armored or engineered cap using beach mix or vegetation. However, the extent excavation and capping under this alternative may not be sufficient to deal with the extent of the contamination in riverbank soils that may recontaminate the river sediments.

The greater extent of capped areas under Alternative D relative to Alternative B would require a greater reliance on ICs such as RNAs.

4.2.3.2 Compliance with ARARs

Alternative D would comply with ARARs. Chemical specific ARARs would be met over time through implementation of a combination of remedial technologies. Location-specific ARARs for the remedy would be addressed during design and implementation of the alternative. Action-specific ARARs would be achieved by meeting all of the substantive requirements during design, construction, implementation, and monitoring of the alternative.

Compliance with Chemical-Specific ARARs

Same as Alternative B, except:

There is less reliance on MNR to achieve these ARARs than Alternative B.

Compliance with Location-Specific ARARs

Same as Alternative B

Compliance with Action-Specific ARARs

Same as Alternative B

4.2.3.3 Long-Term Effectiveness and Permanence

Under Alternative D, approximately 1,637,000 cy of contaminated sediments and riverbank soil covering approximately 140 acres of river bottom and 13,200 lineal feet of riverbank would be permanently removed by dredging or excavating to targeted sediment removal depths. Various caps would be placed over 59 acres of the site. Residuals from dredging and contaminated areas subject to EMNR would be managed with a thin layer sand cover at approximately 328 acres. After construction is completed, the remediated areas would no longer pose unacceptable impacts to humans and the environment.

Magnitude of Residual Risk

Same as Alternative B, except:

RAO 1 – Estimated post-construction cancer risks shown on **Figure 4.2-1** are generally less than 5 x 10^{-5}, which is within EPA's acceptable risk range, but greater than the estimated background risk of 3 x 10^{-6} in several areas.

RAO 2 – Estimated post-construction cancer risks shown on **Figure 4.2-2** are 3 x 10^{-3}; the majority of the risk is between RM 6 and 8. The estimated risks are greater than the upper end of the acceptable risk range and the estimated background risk of 7 x 10^{-5} throughout the main river channel. Residual risks within Swan Island Lagoon would be at the upper end of the acceptable risk range. The estimated post-construction child non-cancer hazards are shown on **Figure 4.2-3a-j** and are less than 50, primarily from PCBs and HxCDF. Post-construction infant non-cancer hazards are generally less than 12,000, primarily from PCBs and dioxins/furans as shown on **Figure 4.2-4a-g**.

RAO 5 – The estimated ecological residual risk at the completion of construction is presented on **Figures 4.2-5a-k**. Post-construction exposures for ecological receptors resulting in a HQ greater than 1 would still exist in localized areas throughout the site. Ecological HQs associated with RAO 5 are less than 30 for BEHP (28), DDx (2), lead (2), and PCBs (2). There are a substantial number of locations where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction (**Figure 4.2-11**). The overall area left to natural recovery processes is less than for Alternative B.

RAO 6 – The estimated ecological residual risk at the completion of construction is provided on **Figures 4.2-6a-i**. Post-construction exposures to ecological receptors through dietary exposure would result in less than 10, primarily for 4,4´-DDE (5), PCBs (3), HxCDF (4), PeCDF (5), and TCDF (7).

Adequacy and Reliability of Engineering and Institutional Controls

Same as B, except:

Alternative D would provide additional controls and be more effective in reducing exposure to risks posed by COCs in the sediments and riverbank soils provided by the increased area of capped material in the site relative to Alternative B. Additional O&M, ICs and monitoring would be required than Alternative B due to the increase in the acreage of caps.

4.2.3.4 Reduction in Toxicity, Mobility and Volume through Treatment

Implementation of Alternative D reduces toxicity, mobility and volume in the same manner as Alternative B.

Treatment Processes Used

Same as Alternative B.

Amount Destroyed or Treated

Under Alternative D, 123 acres of material would be treated in-situ and 395,000 cy of material would be treated ex-situ.

Reduction of Toxicity, Mobility or Volume

Same as Alternative B, except:

- *Broadcast Activated Carbon:* 3.3 acres
- *Reactive Caps:* 27 acres

- *Reactive Residual Management Cover:* 92 acres
- *Significantly Augmented Reactive Cap:* 3.3 acres

In addition, based on the technology assignments for this alternative, the estimated quantity of PTW (source material and not reliably contained) requiring ex-situ treatment is estimated at 395,000 cy. Thermal desorption further reduces the mobility of approximately 25 percent of the dredged material that is PTW.

Irreversible Treatment

Same as Alternative B.

Type and Quantity of Residuals Remaining After Treatment

Same as Alternative B, except:

Implementation of Alternative D would not address 46 percent of the PTW at the site. Therefore, this alternative does not meet the statutory preference for addressing principal threat wastes.

4.2.3.5 Short-Term Effectiveness

The period of construction for this alternatives (5 years) is longer than for Alternative B and involves handling of more dredged materials (1,637,000 cy) and borrow materials (574,000 cy) and would have a longer impact to the community during construction. However, Alternative D would have shorter period of impact to the community and environment until RAOs are met than Alternative B.

Community Protection

Same as Alternative B, except:

Alternative D involves dredging of 164 acres and excavation of 13,200 lineal feet of riverbank, with import of approximately 574,000 cy of borrow material. Impacts from construction and operation activities would occur for a longer time than for Alternative B.

During the construction period, COC concentrations in fish tissue are expected to increase and remain elevated for a longer period of time than for Alternative B. However, this will occur primarily during the work window of July 1 through October 31.

Worker Protection

Same as Alternative B, except:

Potential risks to site workers during the construction period would occur for a longer period of time for than for Alternative B.

Environmental Impacts

Same as Alternative B, except:

Short-term adverse impacts to the river and environment during construction would occur for a longer of time than for Alternative B; however, the time that environmental impacts occur post construction would be less than Alternative B.

Time until Action Complete

Construction operations for this alternative are estimated to take five years. Following the estimated construction time, Alternative D would take less time to meet RAOs and PRGs than Alternative B as the residual contaminant concentrations would be lower and the time for MNR processed to achieve the RAOs and success would be more certain than Alternative B. However, some PRGs are met under this alternative and others are met in some areas of the site at the completion of construction, as discussed below.

RAO 1

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-7a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-2** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-16**.

RAO 2

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-8a-l**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-4** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-17**. The PRG for cPAHs is met under this alternative.

RAO 5

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-9a-o**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-6** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-18**. In addition to the PRGs met under Alternative B, the PRG for DDE is met under this alternative.

RAO 6

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-10a-h**. The SDU SWAC concentrations presented in in **Tables 4.2-1** and **4.2-8** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-19**.

4.2.3.6 Implementability

Alternative D would be readily implementable from both the technical and administrative standpoints. The in-river remedial action as envisioned in this FS can be constructed, operated, and maintained within the site-specific and technology-specific regulations and constraints.

Ability to Construct and Operate

Same as Alternative B, except:

Implementation of Alternative D would involve dredging 1,637,000 cy and handling and placement of 574,000 cy of borrow material. Given the volume of material and project duration for construction, Alternative D would present a slightly greater challenge to implement than Alternative B.

Alternative D has a construction period of approximately five years, involves construction activities within 265 acres, and thus has a low potential for technical difficulties that could lead to schedule delays.

Ease of Doing More Action, if Needed

Same as Alternative B.

Ability to Monitor Effectiveness

Same as Alternative B, except:

Alternative D relies less on reducing contaminant concentrations through MNR (approximately 2,185 acres) than Alternative B. For this reason, additional future remedial actions are predicted to be less likely than Alternative B based on anticipated difficulties in achieving all cleanup objectives.

If monitoring should fail to detect a release in areas where waste has been left in place (caps, EMNR) in a reasonable time frame, then release of COCs to the environment may occur. The risk of this occurring is lower than for Alternative B.

Ability to Obtain Approvals and Coordinate with Other Agencies

Same as Alternative B.

Availability of Specialists, Equipment and Materials

Same as Alternative B, except:

Alternative D requires the more volume of materials than Alternative B; thus, obtaining materials under this alternative would be more difficult than Alternative B.

Availability of Technologies

Same as Alternative B.

4.2.3.7 Cost

Alternative D has higher cost than Alternative B due to the additional construction and monitoring requirements. Total capital costs estimated for this alternative are $1,023,004,000 over 5 years. Total periodic costs (excluding 5-year reviews) are $460,170,000, and the overall net present value cost is $1,105,550,000. The 5-year review periodic costs are $308,000 per event, totaling $1,848,000 over 30 years. Additionally, longer-term costs associated with maintenance and monitoring of contaminants contained on site have been evaluated and estimated to be $817,344,000 ($19,930,000 in present value) over an additional 70 years. Detailed costs associated with implementing Alternative D are presented in Appendix G, and are summarized in Table CS-D.

4.2.4 Alternative E

4.2.4.1 Overall Protection of Human Health and the Environment

Alternative E, in conjunction with MNR and institutional controls, is expected to be protective of human health. Alternative E would address the unacceptable risks to human health through capping, dredging, in-situ treatment and EMNR of 329 acres of contaminated sediments and 16,000 lineal feet of riverbank. The construction duration for this alternative is estimated to be 7 years, with no additional time required to complete dredged material processing.

Reduction in surface-area weighted average concentrations (SWACs) on a site-wide basis for Alternative E following construction as compared to Alternative A (without consideration of MNR) for the RAL COCs are as follows:

- PCBs – 63 percent
- Total PAHs – 90 percent
- DDx – 73 percent
- TCDD – 52 percent
- PeCDD – 44 percent
- PeCDF – 94 percent

Concentrations of other COCs would also be reduced in surface sediment under this alternative.

Direct contact carcinogenic risks are estimated to be less than 2×10^{-5} (**Figure 4.2-1**), which is within the acceptable risk range. Carcinogenic risks associated with consumption of contaminated fish and shellfish (RAO 2) are less than 2×10^{-3}; the majority of the risk is between RM 6 and 8, as presented on **Figure 4.2-2**. The estimated child non-cancer hazard is 40, primarily from PCBs and HxCDF, as shown on **Figure 4.2-3a-j**. Non-cancer hazard to nursing infants is estimated at 8,000, primarily from PCBs and dioxins/furans (**Figure 4.2-4a-g**). Because further reductions in risk are likely to occur from natural recovery processes, Alternative E would require less reliance on fish consumption advisories to attain additional effectiveness than Alternative D.

Following the implementation of Alternative E, ecological HQs exceed 1 for both RAO 5 and 6, as presented on **Figures 4.2-5a-k** and **4.2-6a-i**, respectively. Ecological HQs associated with RAO 5 are less than 30 for BEHP (27), DDx (2), and lead (2). There are fewer locations under Alternative E than in Alternative D where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction as shown on **Figure 4.2-11**. Hazard quotients associated with RAO 6 are less than 5, primarily for 4,4´-DDE (2), PCBs (2), HxCDF (2), PeCDF (3), and TCDF (4). Further risk reductions are likely to occur over time due to natural recovery processes, and the likelihood of achieving RAOs 5 and 6 within a reasonable timeframe are greater than for Alternative D.

Alternative E would achieve RAOs 3 and 7 in a shorter period of time than Alternative D because lower contaminant sediment concentrations are left remaining outside constructed areas, reducing flux to surface water.

The area covered by reactive caps in locations of contaminated groundwater under Alternative E is greater than for Alternative D, reducing the residual risks and the time needed to attain RAOs 4 and 8.

Alternative E has a greater likelihood of achieving RAO 9 than under Alternative D due to additional removal of contaminated riverbank materials and placement of either an armored or engineered cap using beach mix or vegetation. However, the extent excavation and capping under this alternative may not be sufficient to deal with the extent of the contamination in riverbank soils that may recontaminate the river sediments.

The greater extent of capped areas under Alternative E relative to Alternative D would require a greater reliance on ICs such as RNAs.

4.2.4.2 Compliance with ARARs

Alternative E would comply with ARARs. Chemical specific ARARs would be met over time through implementation of a combination of remedial technologies. Location-specific ARARs for the remedy would be addressed during design and implementation of the alternative. Action-specific ARARs would be achieved by meeting all of the substantive requirements during design, construction, implementation, and monitoring of the alternative.

Compliance with Chemical-Specific ARARs

Same as Alternative B, except:

There is less reliance on MNR to achieve these ARARs than Alternative D.

<u>Federal Emergency Management Act</u>

In the 60% Design Report for the Terminal 4 CDF (Port of Portland 2011), a HEC-RAS model was used to determine the potential impacts to the floodplain from construction of the CDF. The HEC-RAS model results indicate that the proposed CDF would not increase the 100-year floodplain or flood way elevations at any location relative to the existing condition. However, the impacts of sedimentation, erosion and debris were not considered in the hydraulic analysis performed, in accordance with FEMA criteria. Sedimentation and erosion can modify the channel geometry of the waterway and possibly affect the model-predicted flood elevations. In addition, the hydraulic analysis addressed only the potential impacts of the proposed CDF to flood elevations and did not consider the issues of slope stability, bankline protection, scour or other geotechnical matters. Additional evaluations would need to be conducted in completing the design of the CDF if it is selected as part of the final remedy to ensure compliance with this ARAR.

Compliance with Action-Specific ARARs

Same as Alternative B, except:

<u>CWA 404 and ESA</u>

The siting, design, and operation of the CDF has been analyzed under the factors specified in the CWA 404(b)(1) guidelines (see 404(b)(1) analysis in the administrative record) such that determination that a CDF can be sited and operated as part of the remedial action in compliance with the CWA. CWA 404(b)(1) requirements including coordination with ESA agencies on mitigation measures to avoid jeopardy will be further analyzed and determined as the final design and final compensatory mitigation determination is made. Long-term maintenance and monitoring of the CDF and necessary compensatory mitigation will comply with the CWA and ESA requirements.

<u>RCRA</u>

All dredged materials and contaminated riverbank materials removed from the Site under Alternative E could be managed under DMM Scenario 1 (onsite CDF/off-site disposal facility) or DMM Scenario 2 (off-site disposal facilities). The Sediment Disposal Decision Tree presented in **Figure 3.6-40** is used to guide the process to determine appropriate disposal options for this material. Although dredge sediment management in the CDF are exempt from regulation as a RCRA hazardous waste, Portland Harbor-specific CDF performance standards (**Table 3.3-8**) do not allow contamination that would meet the definition of a listed or characteristic hazardous waste to be disposed in the CDF. Thus, dredge contaminated sediments having toxicity characteristics will be transported off-site for disposal as shown on the Sediment Disposal Decision Tree.

<u>Oregon Hazardous Waste Regulations</u>

State-listed hazardous waste has been identified off the Arkema site and any dredge material generated from this area will be tested and handled in accordance with Oregon regulations and as shown on **Figure 3.6-40**. This approach would also meet the requirements for management of waste pesticides in OAR 340-109.

<u>Oregon Solid Waste Regulations (relevant provisions of OAR 340-095 for non-municipal landfill regulations):</u>

The CDF will be constructed, filled, maintained and monitored consistent with identified Oregon solid waste regulations for non-municipal landfills.

4.2.4.3 Long-Term Effectiveness and Permanence

Under Alternative E, approximately 2,838,000 cy of contaminated sediments and riverbank soil covering approximately 250 acres of river bottom and 16,000 lineal feet of riverbank would be permanently removed by dredging or excavating to targeted sediment removal depths. Various caps would be placed over 64 acres of the site. Residuals from dredging and contaminated areas subject to EMNR would be managed with a thin layer sand cover at approximately 305 acres. After construction is completed, the remediated areas would no longer pose unacceptable impacts to humans and the environment.

Magnitude of Residual Risk

Same as Alternative D, except:

RAO 1 – Estimated post-construction cancer risks shown on **Figure 4.2-1** are generally less than 2×10^{-5}, which is within EPA's acceptable risk range, but greater than the estimated background risk of 3×10^{-6} in several areas.

RAO 2 – Estimated post-construction cancer risks shown on **Figure 4.2-2** are 2×10^{-3}; the majority of the risk is between RM 6 and 8. The estimated risks are greater than the upper end of the acceptable risk range and the estimated background risk of 7 x 10 5 throughout the main river channel. Residual risks within Swan Island Lagoon would be at the upper end of the acceptable risk range. The estimated post-construction child non-cancer hazards are shown on **Figure 4.2-3a-j** and are less than 40, primarily from PCBs and HxCDF. Post-construction infant non-cancer hazards are generally less than 8,000, primarily from PCBs and dioxins/furans as shown on **Figure 4.2-4a-g**.

RAO 5 – The estimated ecological residual risk at the completion of construction is presented on **Figures 4.2-5a-k**. Post-construction exposures for ecological receptors resulting in a HQ greater than 1 would still exist in localized areas throughout the site. Ecological HQs associated with RAO 5 are less than 30 for BEHP (27), DDx (2), and lead (2). There are a substantial number of locations where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction (**Figure 4.2-11**). The overall area left to natural recovery processes is less than for Alternative D.

RAO 6 – The estimated ecological residual risk at the completion of construction is provided on **Figures 4.2-6a-i**. Post-construction exposures to ecological receptors through dietary exposure would result in less than 5, primarily for 4,4´-DDE (2), PCBs (2), HxCDF (2), PeCDF (3), and TCDF (4).

Adequacy and Reliability of Engineering and Institutional Controls

Same as B, except:

Alternative E would provide additional controls and be more effective in reducing exposure to risks posed by COCs in the sediments and riverbank soils provided by the increased area of capped material in the site relative to Alternative D. Additional O&M, ICs and monitoring would be required than Alternative D due to the increase in the acreage of caps.

4.2.4.4 Reduction in Toxicity, Mobility and Volume through Treatment

Implementation of Alternative E reduces toxicity, mobility and volume in the same manner as Alternative B.

Treatment Processes Used

Same as Alternative B.

Amount Destroyed or Treated

Under Alternative E, 197 acres of material would be treated in-situ and 442,000 cy of material would be treated ex-situ.

Reduction of Toxicity, Mobility or Volume

Same as Alternative B, except:

- *Broadcast Activated Carbon:* 0 acres
- *Reactive Caps:* 39 acres
- *Reactive Residual Management Cover:* 155 acres
- *Significantly Augmented Reactive Cap:* 3 acres

In addition, based on the technology assignments for this alternative, the quantity of PTW (source material and not reliably contained) requiring ex-situ treatment is estimated at 442,000 cy. Thermal desorption further reduces the mobility of approximately 16 percent of the dredged material that is PTW.

Irreversible Treatment

Same as Alternative B.

Type and Quantity of Residuals Remaining After Treatment

Same as Alternative B, except:

Implementation of Alternative E would address all of the PTW at the site.

4.2.4.5 Short-Term Effectiveness

The period of construction for this alternative (7 years) is longer than for Alternative D and involves handling of more dredged materials (2,838,000 cy) and borrow materials (866,000 cy) and would have a longer impact to the community during construction. However, Alternative E would have a shorter period of impact to the community and environment until RAOs are met than Alternative D.

Community Protection

Same as Alternative B, except:

Alternative E involves dredging of 252 acres and excavation of 16,000 lineal feet of riverbank, with import of approximately 866,000 cy of borrow material. Impacts from construction and operation activities would occur for a longer time than for Alternative D.

Construction and operation of a treatment and transport facility and CDF may be necessary. Additional impacts during filling of the CDF would be minimized by monitoring air quality and water quality and through implementation of BMPs.

During the construction period, COC concentrations in fish tissue are expected to increase and remain elevated for a longer period of time than for Alternative D. However, this would occur primarily during the in-water work window of July 1 through October 31.

Worker Protection

Same as Alternative B, except:

Potential risks to site workers during the construction period for Alternative E would occur for a longer period of time than Alternative D.

Environmental Impacts

Same as Alternative B, except:

Short-term adverse impacts to the river during construction would occur for a longer time period than Alternative D; however, the time that environmental impacts occur post construction would be less than Alternative D.

Time until Action Complete

Construction operations for this alternative are estimated to take seven years. Following the estimated construction time, Alternative E would take less time to meet RAOs and PRGs than Alternative D as the residual contaminant concentrations would be lower and the time for MNR processed to achieve the RAOs and success would be more certain than Alternative D. However, some PRGs are met under this alternative and others are met in some areas of the site at the completion of construction, as discussed below.

RAO 1

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-7a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-2** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-20**.

RAO 2

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-8a-l**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-4** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-21**.

RAO 5

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-9a-o.** The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-6** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-22**.

RAO 6

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-10a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-8** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-23**.

4.2.4.6 Implementability

Alternative E would be readily implementable from both the technical and administrative standpoints. The in-river remedial action as envisioned in this FS can be constructed, operated, and maintained within the site-specific and technology-specific regulations and constraints. However, the technical and administrative implementability of the DMM Scenarios vary.

Ability to Construct and Operate

Same as Alternative B, except:

Implementation of Alternative E would involve dredging 2,838,000 cy sediment and the handling and placement of 866,000 cy borrow material. These volumes are greater than required for Alternative D. Given the greater volume of material and project duration for construction, Alternative E would present a greater challenge to implement than Alternative D.

Alternative E assumes construction of a CDF, which pose greater technical and administrative challenges than Alternatives B and D.

Alternative E has a construction period of approximately seven years, involves construction activities within 329 acres, and thus has a greater potential for technical difficulties that could lead to schedule delays than Alternative D.

Ease of Doing More Action, if Needed

Same as Alternative B.

Ability to Monitor Effectiveness

Same as Alternative B, except:

Alternative E relies on reducing contaminant concentrations through MNR (approximately 2,121 acres) than Alternative D. For this reason, additional future remedial actions are predicted to be less likely than for Alternative D based on anticipated difficulties in achieving all cleanup objectives.

If monitoring should fail to detect a release in areas where waste has been left in place (caps, EMNR) in a reasonable time frame, then a release of COCs to the environment may occur. The risk of this occurring is lower than for Alternative D.

Construction of the CDF would impose greater monitoring requirements for this alternative relative to Alternatives B and D.

Ability to Obtain Approvals and Coordinate with Other Agencies

Same as Alternative B.

Availability of Specialists, Equipment and Materials

Same as Alternative B, except:

Since Alternative E requires the more volume of materials than Alternative D; thus, obtaining materials under this alternative would be the more difficult than Alternative D.

Availability of Technologies

Same as Alternative B, except:

Under DMM Scenario 1,670,000 cy dredged materials would be barged to the Terminal 4 CDF site, minimizing on-land impacts to the community, but increasing vessel traffic in the river. Since major container terminals are located in the Willamette River near the assumed CDF site, increased barge traffic to and from the CDF site may interfere with existing commercial port traffic and increase the potential for waterborne commerce accidents. These risks can be managed through engineering and navigation controls established by the dredging and/or materials management contractor working in association with the Port Authority and other regulatory agencies, to control traffic in and around the CDF site.

4.2.4.7 Cost

Alternative E has higher cost than Alternative D due to the additional construction and monitoring requirements. Total capital costs estimated for this alternative are

$1,452,748,000 over 7 years. Total periodic costs (excluding 5-year reviews) are $651,834,000, and the overall net present value cost is $1,490,610,000. The 5-year review periodic costs are $308,000 per event, totaling $1,848,000 over 30 years. Additionally, longer-term costs associated with maintenance and monitoring of contaminants contained on site have been evaluated and estimated to be $1,161,637,000 ($28,300,000 in present value) over an additional 70 years. Detailed costs associated with implementing Alternative E are presented in Appendix G, and are summarized in Table CS-E.

4.2.5 Alternative F

4.2.5.1 Overall Protection of Human Health and the Environment

Alternative F, in conjunction with MNR and institutional controls, is expected to be protective of human health. Alternative F would address the unacceptable risks to human health through capping, dredging, in-situ treatment and EMNR of 538 acres of contaminated sediments and 19,600 lineal feet of riverbank. The construction duration for this alternative is estimated to be 12 years, with no additional time required to complete dredged material processing.

Reduction in surface-area weighted average concentrations (SWACs) on a site-wide basis for Alternative F following construction as compared to Alternative A (without consideration of MNR) for the RAL COCs are as follows:

- PCBs – 75 percent
- Total PAHs – 93 percent
- DDx – 79 percent
- TCDD –61percent
- PeCDD – 54 percent
- PeCDF – 96 percent

Concentrations of other COCs would also be reduced in surface sediment under this alternative.

Direct contact carcinogenic risks are estimated to be less than 1×10^{-5} (**Figure 4.2-1**), which is within the acceptable risk range. Carcinogenic risks associated with consumption of contaminated fish and shellfish (RAO 2) are less than 1×10^{-3}; the majority of the risk is between RM 6 and 8, as presented on **Figure 4.2-2**. The estimated child non-cancer hazard is 30, primarily from PCBs and HxCDF, as shown on **Figure 4.2-3a-j**. Non-cancer hazard to nursing infants is estimated at 7,000, primarily from PCBs and dioxins/furans (**Figure 4.2-4a-g**). Because further reductions in risk are likely to occur from natural recovery processes, Alternative F would require less reliance on fish consumption advisories to attain additional effectiveness than Alternative E.

Following the implementation of Alternative F, ecological HQs exceed 1 for both RAO 5 and 6, as presented on **Figures 4.2-5a-k** and **4.2-6a-i**, respectively. Ecological HQs associated with RAO 5 are less than 25 for BEHP (20), and DDx (2). There are fewer locations under Alternative F than in Alternative E where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction as shown on **Figure 4.2-11**. Hazard quotients associated with RAO 6 are less than 5, primarily for HxCDF (2), PeCDF (2), and TCDF (4). Further risk reductions are likely to occur over time due to natural recovery processes, and the likelihood of achieving RAOs 5 and 6 within a reasonable timeframe are greater than for Alternative E.

Alternative F would achieve RAOs 3 and 7 in a shorter period of time than Alternative E because lower contaminant sediment concentrations are left remaining outside constructed areas, reducing flux to surface water.

The area covered by reactive caps in locations of contaminated groundwater under Alternative F is greater than for Alternative E, reducing the residual risks and the time needed to attain RAOs 4 and 8.

Alternative F has a greater likelihood of achieving RAO 9 than under Alternative E due to additional removal of contaminated riverbank materials and placement of either an armored or engineered cap using beach mix or vegetation. However, the extent excavation and capping under this alternative may not be sufficient to deal with the extent of the contamination in riverbank soils that may recontaminate the river sediments.

The greater extent of capped areas under Alternative F relative to Alternative E would require a greater reliance on ICs such as RNAs.

4.2.5.2 Compliance with ARARs

Alternative F would comply with ARARs. Chemical specific ARARs would be met over time through implementation of a combination of remedial technologies. Location-specific ARARs for the remedy would be addressed during design and implementation of the alternative. Action-specific ARARs would be achieved by meeting all of the substantive requirements during design, construction, implementation and monitoring of the alternative.

Compliance with Chemical-Specific ARARs

Same as Alternative E, except:

There is less reliance on MNR to achieve these ARARs than Alternative E.

Compliance with Location-Specific ARARs

Same as Alternative E

Compliance with Action-Specific ARARs

Same as Alternative E

4.2.5.3 Long-Term Effectiveness and Permanence

Under Alternative F, approximately 5,951,000 cy of contaminated sediments and riverbank soil covering approximately 444 acres of river bottom and 19,600 lineal feet of riverbank would be permanently removed by dredging or excavating to targeted sediment removal depths. Various cps would be placed over 168 acres of the site. Residuals from dredging and contaminated areas subject to EMNR would be managed with a thin layer sand cover at approximately 410 acres. After construction is completed, the remediated areas would no longer pose unacceptable impacts to humans and the environment.

Magnitude of Residual Risk

Same as Alternative E, except:

RAO 1 – Estimated post-construction cancer risks shown on **Figure 4.2-1** are generally less than 1 x 10^{-5}, which is within EPA's acceptable risk range, but greater than the estimated background risk of 3 x 10^{-6} in several areas.

RAO 2 – Estimated post-construction cancer risks shown on **Figure 4.2-2** are 1 x 10^{-3}; the majority of the risk is between RM 6 and 8. The estimated risks are greater than the upper end of the acceptable risk range and the estimated background risk of 7 x 10^{-5} throughout the main river channel. Residual risks within Swan Island Lagoon would be at the upper end of the acceptable risk range. The estimated post-construction child non-cancer hazards are shown on **Figure 4.2-3a-j** and are less than 30, primarily from PCBs and HxCDF. Post-construction infant non-cancer hazards are generally less than 7,000, primarily from PCBs and dioxins/furans as shown on **Figure 4.2-4a-g**.

RAO 5 – The estimated ecological residual risk at the completion of construction is presented on **Figures 4.2-5a-k**. Post-construction exposures for ecological receptors resulting in a HQ greater than 1 would still exist in localized areas throughout the site. Ecological HQs associated with RAO 5 are less than 25 for BEHP (20), and DDx (2). There are a substantial number of locations where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction (**Figure 4.2-11**). The overall area left to natural recovery processes is less than for Alternative E.

RAO 6 – The estimated ecological residual risk at the completion of construction is provided on **Figures 4.2-6a-i**. Post-construction exposures to ecological receptors through dietary exposure would result in less than 5, primarily for HxCDF (2), PeCDF (2), and TCDF (4).

Adequacy and Reliability of Engineering and Institutional Controls

Same as Alternative B, except:

Alternative F would provide additional controls and be more effective in reducing exposure to risks posed by COCs in the sediments and riverbank soils provided by the increased area of capped material in the site relative to Alternative E. Additional O&M, ICs and monitoring would be required than Alternative E due to the increase in the acreage of caps.

4.2.5.4 Reduction in Toxicity, Mobility and Volume through Treatment

Implementation of Alternative F reduces toxicity, mobility and volume in the same manner as Alternative B.

Treatment Processes Used

Same as Alternative B.

Amount Destroyed or Treated

Under Alternative F, 203 acres of material would be treated in-situ and 506,000 cy of material would be treated ex-situ.

Reduction of Toxicity, Mobility or Volume

Same as Alternative B, except:

- *Broadcast Activated Carbon:* 0 acres
- *Reactive Caps:* 67 acres
- *Reactive Residual Management Cover:* 166 acres
- *Significantly Augmented Reactive Cap:* 4 acres

In addition, based on the technology assignments for this alternative, the quantity of PTW (source material and not reliably contained) requiring ex-situ treatment is estimated at 506,000 cy. Thermal desorption further reduces the mobility of approximately 8 percent of the dredged material that is PTW.

Irreversible Treatment

Same as Alternative B.

Type and Quantity of Residuals Remaining After Treatment

Same as Alternative E.

4.2.5.5 Short-Term Effectiveness

The period of construction for this alternative (12 years) is longer than for Alternative E and involves handling of more dredged materials (5,951,000 cy) and borrow materials (1,608,000 cy) and would have a longer impact to the community during construction. However, Alternative F would have shorter period of impact to the community and environment until RAOs are met than Alternative E.

Community Protection

Same as described for Alternative E, except:

This alternative involves dredging of 444 acres and excavation of 19,600 lineal feet of riverbank, with import of approximately 1,608,000 cy of borrow material. Impacts from construction and operation activities would occur over a longer period of time than with Alternative E.

During the construction period, COC concentrations in fish tissue are expected to increase and remain elevated for a longer period of time than for Alternative E. However, this would occur primarily during the in-water work window of July 1 through October 31.

Worker Protection

Same as Alternative B, except:

Potential risks to site workers during the construction period for Alternative F would occur over a longer period of time than Alternative E.

Environmental Impacts

Same as Alternative B, except:

Short-term adverse impacts to the river during construction would occur over a longer period of time than for Alternative E; however, the time that environmental impacts would occur would be less than Alternative E.

Time until Action Complete

Construction operations for this alternative are estimated to take 12 years. Following the estimated construction time, Alternative F would take less time to meet RAOs and PRGs than Alternative E as the residual contaminant concentrations would be lower and the time for MNR processed to achieve the RAOs and success would be more certain than Alternative E. However, some PRGs are met under this alternative and others are met in some areas of the site at the completion of construction, as discussed below.

RAO 1

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-7a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-2** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-24**.

<u>RAO 2</u>

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-8a-l**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-4** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-25**.

<u>RAO 5</u>

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-9a-o**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-6** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-26**. In addition to the PRGs met under Alternative D, the PRGs for copper, lindane and PCBs are met under this alternative.

<u>RAO 6</u>

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-10a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-8** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-27**. In addition to the PRGs met under Alternative B, the PRG for PCBs is met under this alternative.

4.2.5.6 Implementability

Alternative F would be readily implementable from both the technical and administrative standpoints. The in-river remedial action as envisioned in this FS can be constructed, operated, and maintained within the site-specific and technology-specific regulations and constraints. However, the technical and administrative implementability of the DMM Scenarios vary.

Ability to Construct and Operate

Same as Alternative E, except:

Implementation of Alternative F would involve dredging 45,951,000 cy of sediment and the handling and placement of 1,608,000 cy borrow material. These volumes are greater than would be required for Alternative E. Given the greater volume of material and project duration for construction, Alternative F would present a greater challenge to implement than Alternative E.

Alternative F has a construction period of approximately 12 years, involves construction activities within 538 acres, and thus has a greater potential for technical difficulties that could lead to schedule delays than Alternative E.

Ease of Doing More Action, if Needed

Same as Alternative B.

Ability to Monitor Effectiveness

Same as Alternative E, except:

Alternative F relies less on reducing contaminant concentrations through MNR (approximately 1,913 acres) than Alternative E. For this reason, additional future remedial actions are predicted to be less likely than for Alternative E based on anticipated difficulties in achieving all cleanup objectives.

If monitoring should fail to detect a release in areas where waste has been left in place (caps, EMNR) in a reasonable time frame, then a release of COCs to the environment may occur. The risk of this occurring is lower than for Alternative E.

Ability to Obtain Approvals and Coordinate with Other Agencies

Same as Alternative B.

Availability of Specialists, Equipment and Materials

Same as Alternative B, except:

Alternative F requires more volume of materials than Alternative E; thus, obtaining materials under this alternative would be the more difficult than Alternatives E.

Availability of Technologies

Same as Alternative E.

4.2.5.7 Cost

Alternative F has higher cost than Alternative E due to the additional construction and monitoring requirements. Total capital costs estimated for this alternative are $2,388,798,000 over 12 years. Total periodic costs (excluding 5-year reviews) are $803,150,000, and the overall net present value cost is $2,053,600,000. The 5-year review periodic costs are $308,000 per event, totaling $1,848,000 over 30 years. Additionally, longer-term costs associated with maintenance and monitoring of contaminants contained on site have been evaluated and estimated to be $1,436,605,000 ($34,970,000 in present value) over an additional 70 years. Detailed costs associated with implementing Alternative F are presented in Appendix G, and are summarized in Table CS-F.

4.2.6 Alternative G

4.2.6.1 Overall Protection of Human Health and the Environment

Alternative G, in conjunction with MNR and institutional controls, is expected to be protective of human health. Alternative G would address the unacceptable risks to human health through capping, dredging, in-situ treatment and EMNR of 795 acres of contaminated sediments and 22,700 lineal feet of riverbank. The construction duration for this alternative is estimated to be 18 years, with no additional time required to complete dredged material processing.

Reduction in surface-area weighted average concentrations (SWACs) on a site-wide basis for Alternative G following construction as compared to Alternative A (without consideration of MNR) for the RAL COCs are as follows:

- PCBs – 82 percent
- Total PAHs – 96 percent
- DDx – 85 percent
- TCDD –69 percent
- PeCDD – 62 percent
- PeCDF – 97 percent

Concentrations of other COCs would also be reduced in surface sediment under this alternative.

Direct contact carcinogenic risks are estimated to be less than 1×10^{-5} (**Figure 4.2-1**), which is within the acceptable risk range. Carcinogenic risks associated with consumption of contaminated fish and shellfish (RAO 2) are less than 1×10^{-3}; the majority of the risk is between RM 6 and 8, as presented on **Figure 4.2-2**. The estimated child non-cancer hazard is 30, primarily from PCBs and HxCDF, as shown on **Figure 4.2-3a-j**. Non-cancer hazard to nursing infants is estimated at 6,000, primarily from PCBs and dioxins/furans (**Figure 4.2-4a-g**). Because further reductions in risk are likely to occur from natural recovery processes, Alternative G would require less reliance on fish consumption advisories to attain additional effectiveness than Alternative F.

Following the implementation of Alternative G, ecological HQs exceed 1 for both RAO 5 and 6, as presented on **Figures 4.2-5a-k** and **4.2-6a-i**, respectively. Ecological HQs associated with RAO 5 are less than 10 for BEHP (8), and DDx (2). There are fewer locations under Alternative G than in Alternative F where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction as shown on **Figure 4.2-11**. Hazard quotients associated with RAO 6 are less than 5, primarily for HxCDF (2), PeCDF (2), and TCDF (3). Further risk reductions are likely to occur over time due to natural recovery processes, and the likelihood of achieving RAOs 5 and 6 within a reasonable timeframe are greater than for Alternative F.

Alternative G would achieve RAOs 3 and 7 in a shorter period of time than Alternative F because lower contaminant sediment concentrations are left remaining outside constructed areas, reducing flux to surface water.

The area covered by reactive caps in locations of contaminated groundwater under Alternative G is greater than for Alternative F, reducing the residual risks and the time needed to attain RAOs 4 and 8.

Alternative G has a greater likelihood of achieving RAO 9 than under Alternative F due to additional removal of contaminated riverbank materials and placement of either an armored or engineered cap using beach mix or vegetation. However, the extent excavation and capping under this alternative may not be sufficient to deal with the extent of the contamination in riverbank soils that may recontaminate the river sediments.

The greater extent of capped areas under Alternative G relative to Alternative F would require a greater reliance on ICs such as RNAs.

4.2.6.2 Compliance with ARARs

Alternative G would comply with ARARs. Chemical specific ARARs would be met over time through implementation of a combination of remedial technologies. Location-specific ARARs for the remedy would be addressed during design and implementation of the alternative. Action-specific ARARs would be achieved by meeting all of the substantive requirements during design, construction, implementation and monitoring of the alternative.

Compliance with Chemical-Specific ARARs

Same as Alternative E, except:

There is less reliance on MNR to achieve these ARARs than Alternative F.

Compliance with Location-Specific ARARs

Same as Alternative E.

Compliance with Action-Specific ARARs

Same as Alternative E.

4.2.6.3 Long-Term Effectiveness and Permanence

Under Alternative G, approximately 9,278,000 cy of contaminated sediments and riverbank soil covering approximately 640 acres of river bottom and 22,700 lineal feet of riverbank would be permanently removed by dredging or excavating to targeted sediment removal depths. Various caps would be placed over 191 acres of the site. Residuals from dredging and contaminated areas subject to EMNR would be managed with a thin layer sand cover at approximately 579 acres. After construction is completed, the remediated areas would no longer pose unacceptable impacts to humans and the environment.

Magnitude of Residual Risk

Same as Alternative F, except:

RAO 1 – Estimated post-construction cancer risks shown on **Figure 4.2-1** are generally less than 1 x 10^{-5}, which is within EPA's acceptable risk range, but greater than the estimated background risk of 3 x 10^{-6} in several areas.

RAO 2 – Estimated post-construction cancer risks shown on **Figure 4.2-2** are 1 x 10^{-3}; the majority of the risk is between RM 6 and 8. The estimated risks are greater than the upper end of the acceptable risk range and the estimated background risk of 7 x 10^{-5} throughout the main river channel. Residual risks within Swan Island Lagoon would be at the upper end of the acceptable risk range. The estimated post-construction child non-cancer hazards are shown on **Figure 4.2-3a-j** and are less than 30, primarily from PCBs and HxCDF. Post-construction infant non-cancer hazards are generally less than 6,000, primarily from PCBs and dioxins/furans as shown on **Figure 4.2-4a-g**.

RAO 5 – The estimated ecological residual risk at the completion of construction is presented on **Figures 4.2-5a-k**. Post-construction exposures for ecological receptors resulting in a HQ greater than 1 would still exist in localized areas throughout the site. Ecological HQs associated with RAO 5 are less than 10 for BEHP (8), and DDx (2). There are a substantial number of locations where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction (**Figure 4.2-11**). The overall area left to natural recovery processes is less than for Alternative F.

RAO 6 – The estimated ecological residual risk at the completion of construction is provided on **Figures 4.2-6a-i**. Post-construction exposures to ecological receptors through dietary exposure would result in less than 5, primarily for HxCDF (2), PeCDF (2), and TCDF (3).

Adequacy and Reliability of Engineering and Institutional Controls

Same as Alternative B, except:

Alternative G would provide additional controls and be more effective in reducing exposure to risks posed by COCs in the sediments and riverbank soils provided by the increased area of capped material in the site relative to Alternative F. Additional O&M, ICs, and monitoring would be required than Alternative F due to the increase in the acreage of caps.

4.2.6.4 Reduction in Toxicity, Mobility and Volume through Treatment

Implementation of Alternative G reduces toxicity, mobility and volume in the same manner as Alternative B.

Treatment Processes Used

Same as Alternative B.

Amount Destroyed or Treated

Under Alternative G, 238 acres of material would be treated in-situ and 528,000 cy of material would be treated ex-situ.

Reduction of Toxicity, Mobility or Volume

Same as Alternative B, except:

- *Broadcast Activated Carbon:* 0 acres
- *Reactive Caps:* 83 acres
- *Reactive Residual Management Cover:* 187 acres
- *Significantly Augmented Reactive Cap:* 4 acres

In addition, based on the technology assignments for this alternative, the quantity of PTW (source material and not reliably contained) requiring ex-situ treatment is estimated at 528,000 cy. Thermal desorption further reduces the mobility of approximately 6 percent of the dredged material that is PTW.

Irreversible Treatment

Same as Alternative B.

Type and Quantity of Residuals Remaining After Treatment

Same as Alternative E.

4.2.6.5 Short-Term Effectiveness

The period of construction for Alternative G (18 years) is longest and involves handling of the most dredged materials (9,278,000 cy) and borrow materials (2,434,000 cy) and would have the longest impact to the community during construction. However, Alternative G would have the shortest overall period of impact to the community and environment until RAOs are met.

Community Protection

Same as Alternative E, except:

Alternative G involves dredging of 640 acres and excavation of 22,700 lineal feet of riverbank, with import of approximately 2,434,000 cy of borrow material. Impacts from construction and operation activities would occur for the longest period of time under this.

During the construction period, COC concentrations in fish tissue are expected to increase and remain elevated for the longest period of time. However, this would occur primarily during the in-water work window of July 1 through October 1.

Workers Protection

Same as Alternative B, except:

Potential risks to site workers during the construction period for Alternative G would occur for a longer period of time than for the other alternatives.

Environmental Impacts

Same as Alternative B, except:

Short-term adverse impacts to the river during construction would occur for the longest period of time; however, the time that environmental impacts occur would be the shortest period of time.

Time until Action Complete

Construction operations for this alternative are estimated to take 18 years. Following the estimated construction time, Alternative G would take less time to meet RAOs and PRGs than Alternative F as the residual contaminant concentrations would be lower and the time for MNR processed to achieve the RAOs and success would be more certain than Alternative F. However, some PRGs are met under this alternative and others are met in some areas of the site at the completion of construction, as discussed below.

RAO 1

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-7a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-2** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-28**.

RAO 2

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-8a-l**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-4** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-29**. In addition to the PRGs met under Alternative D, the PRGs for aldrin, chlordanes, and TCDD are met under this alternative.

RAO 5

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-9a-o**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-6** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-30**. In addition to the PRGs met under Alternative F, the PRGs for lead is met under this alternative.

RAO 6

The areas where PRGs for this RAO are exceeded are provided in **Figures 4.2-10a-h**. The SDU SWAC concentrations presented in **Tables 4.2-1** and **4.2-8** were also used for this evaluation. The SDUs where PRGs are met for this RAO is presented in **Table 4.2-**

31. In addition to the PRGs met under Alternative F, the PRG for DDE is met under this alternative.

4.2.6.6 Implementability

Alternative G would be readily implementable from both the technical and administrative standpoints. The in-river remedial action as envisioned in this FS can be constructed, operated, and maintained within the site-specific and technology-specific regulations and constraints. However, the technical and administrative implementability of the DMM Scenarios vary.

Ability to Construct and Operate

Same as Alternative E, except:

Implementation of Alternative G would involve dredging 69,278,000 cy of material and handling and placement of 2,434,000 cy borrow material. These volumes are greater than would be required for the other alternatives. Given this alternative has the greatest volume of material and project duration for construction, Alternative G would present the greatest challenge to implement.

Alternative G has a construction period of approximately 19 years, involves construction activities within 795 acres, and thus has the greatest potential for technical difficulties that could lead to schedule delays.

Ease of Doing More Action, if Needed

Same as Alternative B.

Ability to Monitor Effectiveness

Same as Alternative B, except:

Alternative G relies on reducing contaminant concentrations through MNR (approximately 1,655 acres). For this reason, some additional future remedial actions are predicted to be less likely for Alternative G than for other alternatives based on monitoring data indicating inadequate performance in achieving all cleanup objectives.

If monitoring should fail to detect a release in areas where waste has been left in place (caps, EMNR) in a reasonable time frame, then release of COCs to the environment may occur. The risk of this occurring is the lowest for this alternative.

Ability to Obtain Approvals and Coordinate with Other Agencies

Same as Alternative B.

Availability of Specialists, Equipment and Materials

Same as Alternative B, except:

Alternative G requires the most volume of materials; thus, obtaining materials under this alternative would be the most difficult.

Availability of Technologies

Same as Alternative E.

4.2.6.7 Cost

Alternative G has higher cost than Alternative F due to the additional construction and monitoring requirements. Total capital costs estimated for this alternative are \$3,355,667,000 over 18 years. Total periodic costs (excluding 5-year reviews) are \$977,724,000, and the overall net present value cost is \$2,446,450,000. The 5-year review periodic costs are \$308,000 per event, totaling \$1,848,000 over 30 years. Additionally, longer-term costs associated with maintenance and monitoring of contaminants contained on site have been evaluated and estimated to be \$1,751,940,000 (\$42,640,000 in present value) over an additional 70 years. Detailed costs associated with implementing Alternative G are presented in Appendix G, and are summarized in Table CS-G.

4.3 COMPARATIVE ANALYSIS

The following discussion provides a comparative analysis of the remedial alternatives for each of the seven NCP criteria discussed, above. A summary of the comparative analysis of alternatives is presented in **Table 4.3-1**. A qualitative depiction of the summary is presented in **Table 4.3-2**, where the threshold criteria are depicted as being achieved and the balancing criteria are ranked from lowest relative rank to the highest relative rank.

4.3.1 Overall Protection of Human Health and the Environment

Alternative A would not be protective of human health and the environment and the resuspension of contaminated sediments in the site would continue to impact surface sediments, surface water, and biota and pose unacceptable risks to human health and the environment for the foreseeable future. Because no further action is taken, Alternative A would result in minimal reductions in COC concentration and related residual risks. Natural recovery process would result reduction in the COC concentrations over time, but are unlikely to achieve all PRGs for COCs or meet all RAOs in a reasonable time frame.

Alternatives B through G, in conjunction with MNR and institutional controls, are expected to be protective of human health. Alternative B reduce post-construction contaminant concentrations through capping, dredging, in-situ treatment or EMNR of 200 acres of contaminated sediments. Alternative G would address the greatest amount of area through construction through construction of 795 acres of capping, dredging, in-situ treatment, and EMNR. The in-river construction duration of 4 years is shortest for Alternative B, and at 18 years is longest for Alternative G.

Reductions in post-construction surface-area weighted average concentrations (SWACs) decrease the least under Alternative B, increasing as the area capped and removed via dredging increases, and are the lowest for Alternative G.

Post-construction carcinogenic risks and non-cancer hazard are general greater for Alternative B and decrease through Alternative G. Further risk reductions in risk and hazards are expected due to natural recovery processes and maintenance of institutional controls. Although the timeframe for achieving RAOs is uncertain, Alternative G is likely to achieve RAOs in a shorter timeframe relative to other alternatives because of less reliance on MNR.

Alternative B would be less protective of ecological receptors at the completion of construction compared to Alternatives D though G, as PRGs for a greater number of contaminants are achieved post-construction for Alternative G. There are a substantial number of locations where unacceptable benthic risk (identified via bioassays or predicted via the LRM) are not encompassed by the areas of construction, Alternative B addresses the least of these areas, and Alternative G the greatest number. However, the degree to which the benthic risk areas not addressed by construction activities, and the timeframe in which they might recover is uncertain.

Since Alternative B leaves the greatest amount of sediment contamination in place, depending on dilution and dispersion to reduce overall concentrations, and Alternative G the least, the potential for achieving RAOs 3 and 7 is greater for Alternative G and least for Alternative B. Alternative B is less effective at achieving RAOs 4 and 8 as the overall area of reactive caps is least for Alternative B and greatest for Alternative G.

Because overall post-construction sediment concentrations are highest for Alterative B and lowest for Alternative G, contaminant concentrations in fish and shellfish are expected to recover quickest for G and slowest for B. Thus, there is greater reliance on fish-consumption advisories under Alternative B and least reliance for Alternative G. Conversely, Alternative G requires implementation of a greater area of RNAs compared to Alternative B because of the greater area capped.

4.3.2 Compliance with ARARs

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as “ARARs,” unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not “applicable” to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

All alternatives, except the no action alternative, will attain their respective Federal and State ARARs. Alternatives B through G had common ARARs associated with the construction of the alternative since they are all essentially the same remedial technologies with varying degrees of area and scope. If an on-site CDF is used or treatment and transloading facility, additional ARARs are invoked, but as the prior analysis discussed such ARARs can be met.

4.3.3 Long-Term Effectiveness and Permanence

The resulting risks and hazards following the completion of construction are greatest under Alternative B and least under Alternative G. Because contamination within the SMAs is either capped or removed, the overall concentrations of sediment available for resuspension is less than under Alternative G relative to Alternative B, and there is less potential for recontamination of capped/dredged areas and areas subject to MNR processes. The time needed for MNR to achieve the RAOs is greatest for Alternative B and least for Alternative G.

Sediment removal, capping, and thin layer covers are reliable and proven technologies as long as they are designed for the appropriate environmental and anthropogenic conditions. Offsite thermal destruction (incineration) and land-based disposal facilities are in operation and have proven to be reliable technologies.

The least amount of monitoring and maintenance of caps is needed for Alternative B, increasing for each subsequent alternative and is greatest for Alternative G. Operation and maintenance activities, ICs and long-term monitoring needed to be implemented to assure protectiveness and reliability of caps and thin layer covers increases with the amounted of capped areas, and is less for Alternative B relative to Alternative G.

Overall, Alternative B would require greater reliance on fish consumption advisories, and relatively less reliance on the advisories is needed for Alternative G.

The amount of area requiring land use restrictions is directly proportional to the acreage of caps, and is least for Alternative B, increasing with each successive alternative and is greatest with Alternative G.

4.3.4 Reduction in Toxicity, Mobility and Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternative A does not include treatment as a component of the remedy. Therefore, this alternative would not reduce the toxicity, mobility or volume of contamination at the site.

Alternatives B through G includes in-situ and ex-situ treatment technologies. PTW and groundwater contamination is addressed through treatment for Alternatives B through G and as a result, the preference for treatment as a principle element of the remedial action is met for all alternatives. Reduction in mobility of other contaminants would be through removal and sequestration in a permitted landfill or CDF, or sequestration under in-situ caps. However, there would be no reduction of toxicity or volume through permanent or irreversible treatment. Reduction of the mobility and volume contaminants in groundwater entering the river would be through reactive caps where the reactive layer would isolate the contaminants. In general, the reduction of toxicity, mobility, and volume increases in direct proportion to the construction acreage, where Alternative B would provide the least reduction and Alternative G would provide the most reduction. As the construction acreage increases with each alternative, the reduction of toxicity, mobility, and volume increases as well.

Ex-situ treatment of PTW in contaminated sediments and riverbank soils is determined by the action-specific ARARs, such as LDRs. All PTW treated ex-situ in Alternatives B through G is assumed to be disposed at a RCRA Subtitle C facility. The specific methods of treatment and associated treatment target levels of contaminants will be determined by the facility based on requirements of action-specific ARARs, such as identification of hazardous waste and compliance with LDRs under RCRA. The Subtitle C disposal facility selected as a representative process option (Chem Waste) uses treatment processes such as cement stabilization or thermal desorption, as needed, to meet LDRs for hazardous waste. The toxicity, mobility, and volume of the COCs undergoing thermal treatment would be reduced by more than 99 percent. Solidification/ stabilization would further reduce the mobility of the remaining contaminants. The actual amount of material subject to ex-situ treatment would depend on the results of waste characterization testing during the design phase. In addition, the mobility of contaminants would be further reduced by placing it in a permitted landfill (through sequestration in a landfill cell), although it is not due to permanent and irreversible treatment.

4.3.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternative A would not be an effective alternative because current risks to human health and the environment would continue to exist. However, there are no construction activities planned for Alternative A; thus, there are no risks to the community or workers from construction activities for Alternative A. Risks to the community and environment would continue as a result of exposures to the contaminated media. Fish consumption advisories issued by OHA would continue under Alternative A.

Implementation of Alternative B would have the least impact to the community, workers, and the environment during construction while Alternative G would have the longest impact. However, Alternative B would have the longest impact to the community and environment until RAOs are met, while Alternative G would have the shortest impact. There is some risk of short-term impacts to the community of exposure to from contaminated sediments and riverbank materials during the construction periods for all alternatives. Construction and on-site disposal of a CDF would also impose short-term impacts to the community. Additional impacts during filling of the CDF would be minimized by monitoring air quality and water quality and through implementation of BMPs. Off-site disposal may result in on-land impacts to the community through increased vehicular traffic (through direct transport to off-site disposal facilities or to rail transfer facilities) with an increased accident risk and air-quality issues associated with dust, odor, and vehicular exhaust. Measures to minimize short-term risks to the community will be addressed through implementation of health and safety plans and the use of BMPs. Elevated fish tissue concentrations during construction would be shorter for Alternative B and longest for Alternative G. Fish consumption advisories would continue under each alternative until such time as Remedial Action Objectives (RAOs) are achieved.

There would be potential risks to construction workers during construction activities in Alternatives B through G. However, measures such as air monitoring on-site and at the site boundary, and engineering controls would control the potential for exposure. Risks to workers would be the least in Alternative B, increasing through Alternative G. Workers would be required to wear appropriate levels of protection to avoid exposure during excavation and treatment activities.

Environmental risks during construction would be shortest for Alternative B and increasing through Alternative G. Short-term risks to the environment could include increased emissions from construction equipment and transportation methods for transport of dredged material and imported borrow for caps and residual layers. Short-term risks would be controlled through BMPs, engineering control measures, restricting in-water work time frames (July 1st through October 31st). Appropriate precautions and controls will be used to prevent incidental and accidental discharges of toxic materials from entering the water column as a result of in-water work. The application of emissions reduction strategies during implementation of this alternative can reduce short-term impacts posed to the environment and promote technologies and practices that are sustainable according to the EPA Region 10 Clean and Green Policy. Environmental impacts would continue until RAOs are achieved. Impacts would be longer for Alternative B and decreasing through Alternative G. Environmental impacts to human health via consumption would be controlled through fish consumption advisories.

Alternative B has the shortest construction period and the longest time until the action complete. The construction period increases with each alternative while the time to achieve RAOs decreases.

4.3.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

There are no implementability issues with Alternative A. A ROD amendment may be required in the future if further actions under CERLA are required. Since there is no monitoring required under Alternative A, failure to detect contamination means a potential for consuming contaminated fish and shellfish as well as exposures to other media.

The in-river construction activities required for the implementation of Alternative B through G would be technically feasible and have been implemented at many Superfund sites around the country. Materials, services and equipment necessary for construction are readily commercially available.

In general, the potential for technical problems and schedule delays increases in direct proportion to the duration, and amount of active remediation. As the construction acreage increases with each alternative, the construction period, required administrative coordination, and the potential for technical problems leading to schedule delays increases. The site logistics of implementation also increases in difficulty as more construction acreage is added in each alternative.

Conversely, alternatives with the smallest acreage of construction have a greater potential for triggering additional actions if monitoring data indicates inadequate performance in achieving all cleanup objectives. The risk of monitoring failing to detect a release in areas where waste has been left in place (caps, EMNR or areas) in a reasonable time frame then release of contaminants of concern (COCs) may occur to the environment is indirectly proportional to the acreage.

Installation of the treatment, storage and transfer facility would require cooperation from the landowner and coordination with local authorities for the construction of utilities within existing right-of-ways.

The CDF component of DMM Scenario 1 in Alternatives E, F and G would be administratively challenging from the standpoint of using, and maintaining a CDF facility. Construction of a CDF increases the relative amount of construction for Alternatives E, F and G, and will require sequencing remedial projects for effective CDF use; potential disruption of navigation and other waterway uses throughout construction, filling, and closure; and obtaining agreements among multiple parties for CDF use; costs; maintenance; and liability.

4.3.7 Cost

The estimated present worth costs for the alternatives, not including the No Action alternative, range from $791 million for Alternative B to $2.4 billion for Alternative G. The cost of each alternative increases as the degree of construction increases. Cost summaries can be found in **Table 4.3-1**.

4.3.7.1 Sensitivity Analysis

A sensitivity analyses was performed to obtain a better understanding of the impacts of various cost drivers on the total costs (both constant dollar (non-discounted) costs and present value dollar (discounted) costs). A summary of the conclusions for each sensitivity analysis is presented below:

<u>Period of Analysis Assumptions</u> (30 years versus 100 years): The constant dollar costs for each alternative increase as the periods of analyses increase. However, the constant dollar expenditures after year 30 have minimal effects on the present value costs. The present value costs are generally not sensitive to changes to period of analysis beyond 30 years.

<u>Monitoring Frequency Assumptions</u> (currently assumed O&M Frequency vs. 5-year frequency): Reducing the frequency of O&M has a small to moderate impact on the total present value cost.

<u>Subtitle C/TSCA Disposal Volume Assumptions</u> (current Subtitle C/TSCA disposal volume vs. Subtitle C disposal volume ± 15%): Reducing and increasing the volumes of Subtitle C by 15% has minimal effects on the total present value cost. There is some minor sensitivity between alternatives (i.e. there is a greater magnitude in cost impacts for Alternative B than Alternative G) due to the increased volumes of overall dredging independent of the disposal assumptions.

<u>Construction Duration Assumptions</u> (currently assumed construction duration versus construction duration ± 50%): Reducing and increasing the construction duration assumptions has a relatively significant effect on the total present value cost compared to the other sensitivity analysis scenarios. Shorting the construction durations has a slightly higher effect on sensitivity for all alternatives compared to lengthening the construction duration.

<u>Overdredge Assumptions</u> (current overdredge factor assumption [1.75] vs. low/high overdredge factor [1.50/2.0]): Reducing and increasing the overdredge factor has a small to moderate impact on the total present value cost.

4.3.7.2 DMM Scenario Comparison

A comparison of the total costs (both constant dollar (non-discounted) costs and present value dollar (discounted) costs) for the two disposed material management (DMM) scenarios was performed to understand the cost difference (potential savings) between the two scenarios for Alternatives E, F and G.

The constant dollar (non-discounted) cost difference between DMM Scenarios 2 and 1 for Alternatives E, F, and G that represent potential cost savings is approximately $35,290,000. The present value dollar (discounted) cost difference between DMM Scenarios 2 and 1 for Alternatives E, F, and G are approximately $29,070,000, $24,990,000, and $21,100,000 respectively. Additional information is provided in Attachment C of Appendix G.

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